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Report Number 2517

**Evaluation of the High Sea State
Container Transfer System (HISEACOTS)
and Pontoon Air Cushion Kit (PACK)
Technology Demonstration During Joint
Logistics Over-the-Shore (J-LOTS III-91)**

by
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April 1992

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Preface

The Joint Logistics-Over-the-Shore (J-LOTS III) portion of *Display Determination 91* exercise took place at Fort Story, VA, from 4-26 September 1991, with the US Transportation Command (143d TRANSCOM) acting as on-site Joint Task Force (JTF) operational commander. The Army 11th Transportation Task Force and the US Navy Beach Group Two conducted the joint operations. This test involved the deployment and discharge of a SEABEE, Roll-on/Roll-off (RO/RO), and Auxiliary Crane Ship (T-ACS) vessels. Operations included installation and use of the RO/RO Discharge Platform (RRDP); loading of nonstandard cargo including SEASHEDS and flatracks; ship-to-shore transfer of wheeled/tracked and container cargo; construction of the elevated causeway (ELCAS) and floating causeway pier; and beach stabilization. Tests also demonstrated new and emerging technologies and equipment for cargo offload and transportation.

The Army's current Modular Causeway Sections (MCS) cannot traverse shallow beach gradients or LOTS sites that have restrictive hydrographic features such as offshore sand bars and coral reefs. In addition, the US Army does not have the amphibious capability to carry heavy, outsized cargo in a LOTS operation. The current Lighter, Amphibious, Resupply Cargo-60 ton (LARC-LX) cannot carry the Army's heaviest piece of LOTS equipment, the 140-ton capacity crane (92 short ton tactical disassembly weight). Along with its poor mobility over soft bottom terrain, the LARC-LX also has a very narrow cargo well deck, preventing top loading equipment like the M1A1 tank from supply ships out in the stream.

The Belvoir Research, Development and Engineering Center (BRDEC) developed the Pontoon Air Cushion Kit (PACK) technology demonstrator to enhance MCS mobility and amphibious capability during LOTS operations. This technical report summarizes the results of these technology demonstrations during the J-LOTS III exercises.

J-LOTS I and II exercises identified the need to improve productivity and efficiency by expanding cargo offload capability in high sea states/swell conditions. These exercises revealed severe deficiencies during in-stream offloading/backloading in sea states 3 and above (>3.5-foot waves). Severe

relative motion and pendulation experienced by the lighters and cargo slowed operations dramatically. The potential for damage to lighterage attempting to moor next to the crane ship caused concern.

BRDEC developed the High Sea State Container Transfer System (HISEACOTS) technology demonstrator to enable in-stream container cargo transfer from crane ships to Army hovercraft lighterage in high sea states.

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Section I

Background

J-LOTS III Joint Test and Evaluation (JT&E) is chartered by the Office of the Secretary of Defense, Deputy Director of Defense Research and Engineering, and sponsored by the US Transportation Command.

The United States Army, Navy, Marine Corps, and Air Force are the participating services, with the Army as lead service for JT&E.

J-LOTS III incorporates three stages of testing to enhance overall test efficiency and reduce cost. The first stage joined in the *Display Determination 91* joint exercise. The second stage will involve bulk liquid operations within the *Gallant Eagle 92* exercise, and the third and final stage of J-LOTS III will be sustainment testing during the *Solid Shield 93* exercise.

The Army presently utilizes modular pontoons, some of which are bolted and welded together, to construct field-assembled causeways, causeway ferries, warping tugs, and RO/RO discharge platforms for use in a LOTS operation. The Army recently added International Standards Organization (ISO) compatible modular pontoons to its inventory. These modular pontoons are compatible with commercial type container handling gear and can be shipped by containership. Retractable pin connectors enable fast and rigid connection of the modules.

The PACK is designed to outfit the Army's MCS with an air cushion skirt and autonomous air-supply units that enable it to operate as an air-cushion supported platform. The PACK system can be installed on and removed from an MCS either on the deck of a ship or on land. The PACK requires no modification to the MCS; the skirt system and the air-supply units attach directly to the pontoon's locking connectors and deck fixtures. It is transportable in a commercial 40 foot open top container. The PACK is equipped with two lift-air, skid-mounted supply units that use centrifugal fans (92,000 cfm @ 150 psi) and GM 8-92TA diesel engines (350 HP). The PACK skirt system is fabricated from a 30-ounce, urethane-coated nylon reinforced material. Four steel push knees provide fendering and mooring. Army watercraft assets such as the Lighter, Air Cushion Vehicle (LACV-30), LARC-LX, and Landing Craft Utility-2000 (LCU-2000) can be used for moving the PACK-equipped MCS to the beach. The PACK technology demonstrator, tested in *Display Determination 91* and documented in this report, is shown in Figure 1. Its main characteristics are shown in Table 1.

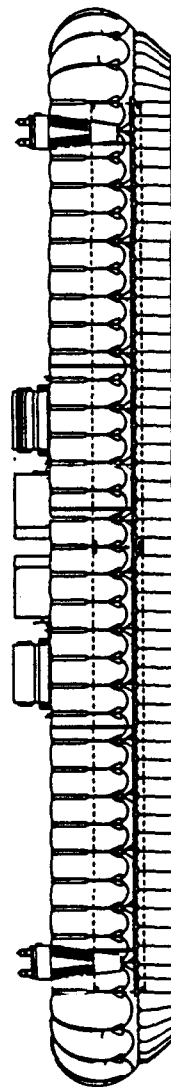
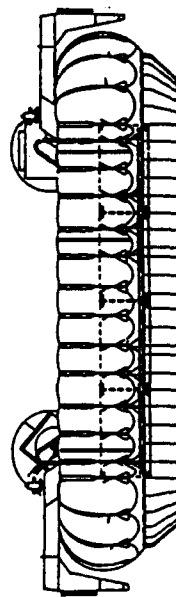
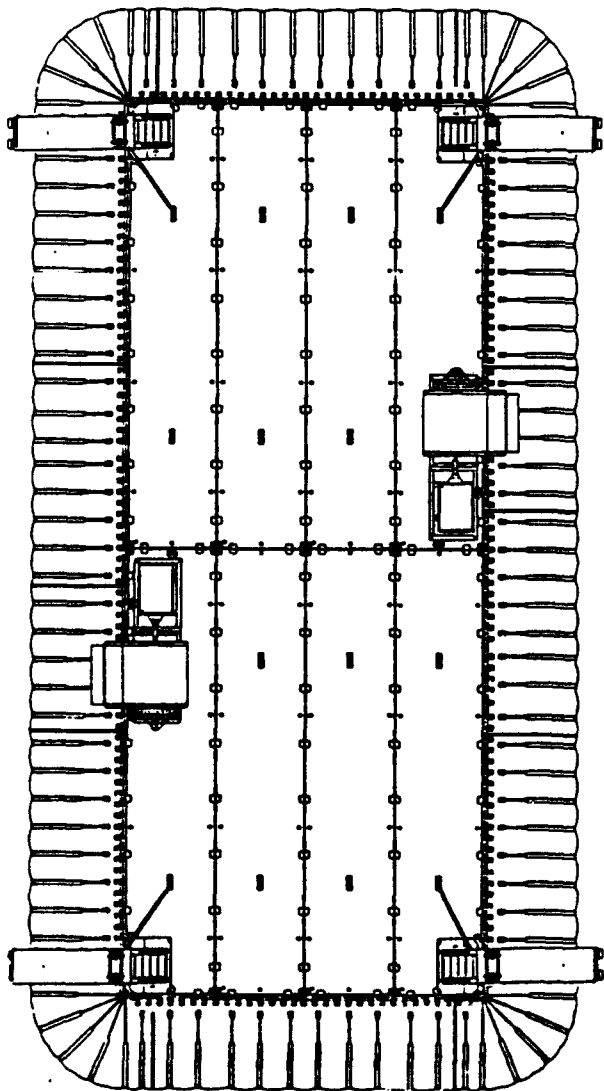


Figure 1. Pontoon Air Cushion Kit (PACK)

Table 1. PACK Characteristics

Length Overall (LOA)	80 feet
Beam (Hard structure)	32 feet
LOA (Inflated)	97 feet
Beam (Inflated)	49 feet
Height (Hard structure)	4.5 feet
Height (On-Cushion)	11 feet
Cushion Height	3 feet
Cushion Length	85 feet
Cushion Beam	37 feet
Lightship Displacement	230,000 pounds
Full Load Displacement	490,000 pounds
Cushion Area	3,145 square feet
Cushion Peripheral Length	241 feet
Cushion Pressure (Full Load)	156 pounds per square foot
Bag-to-Cushion Pressure Ratio (Full Load)	1.15:1
Cushion Airflow	2,500 to 3,500 cubic feet per second

LOTS involves the in-stream discharge of military equipment and supplies from offshore strategic sealift vessels and their transportation ashore aboard lighterage. Strategic sealift with shallow draft or amphibious marine craft collectively termed "lighterage" is required for 95 percent of our force deployment and resupply. Offloading of containers and heavy outsized equipment in high sea states or large ground swell is severely limited by the extreme movement of the lighterage, relative to that of the crane ship, and the pendulation motion of the cargo. Current LOTS offloading operations virtually cease in sea states 3 or above. (Sea state three is characterized by a wave height of 3.5 to 5 feet from crest to trough.) According to a study conducted by the Naval Coastal Systems Center, sea states 3 and above are likely to occur 75 percent of the time at strategically located LOTS sites worldwide.¹

The HISEACOTS consists of a platform formed by the assembly of 8 feet wide x 40 feet long x 4.5 feet high square-end and 8 feet wide x 20 feet long x 4.5 feet high raked-end modular pontoons currently being added to the inventory. This platform is securely moored alongside the T-ACS and provides a stable landing platform for the Lighter Air Cushion Vehicle-30 Ton (LACV-30) during offload operations. The platform utilizes inverted raked-end modules as ramps, which allows the LACV-30 to fly onto the platform at

one end and off from the other. The platform is fitted with batterboards and arresting gates to safely guide and align the LACV-30 onto the platform during high sea state operations. The platform is outfitted with a specially designed traversing gantry crane that accepts the transfer of a container from the T-ACS crane and then spots and lowers the container to the deck of the LACV-30 without problems associated with pendulation or relative motion. The HISEACOTS technology demonstrator, as tested during *Display Demonstration 91* and documented in this report, is shown in Figure 2. Its main characteristics appear in Table 2.

Table 2. HISEACOTS Characteristics

Overall Length	160 feet
Entrance Ramp Beam	88 feet
Exit Ramp Beam	72 feet
Middlebody Beam	56 feet
Fly-Through Width	40 feet
Overall Height	41 feet (Gantry: 36.4 feet)
Entrance Freeboard	22 inches
Exit Freeboard	34 inches
Weight (Light)	513.4 short tons
– Gantry Crane	13.4 short tons
– Platform	500 short tons
Full Load Weight	593 short tons (w/LACV-30 + one 22 short ton container)
Gantry Crane Design Capacity	25 short ton container
Pendulation Limits	+15 feet lateral displacement –15 feet lateral displacement
Heave Limits	+5 feet vertical displacement –5 feet vertical displacement

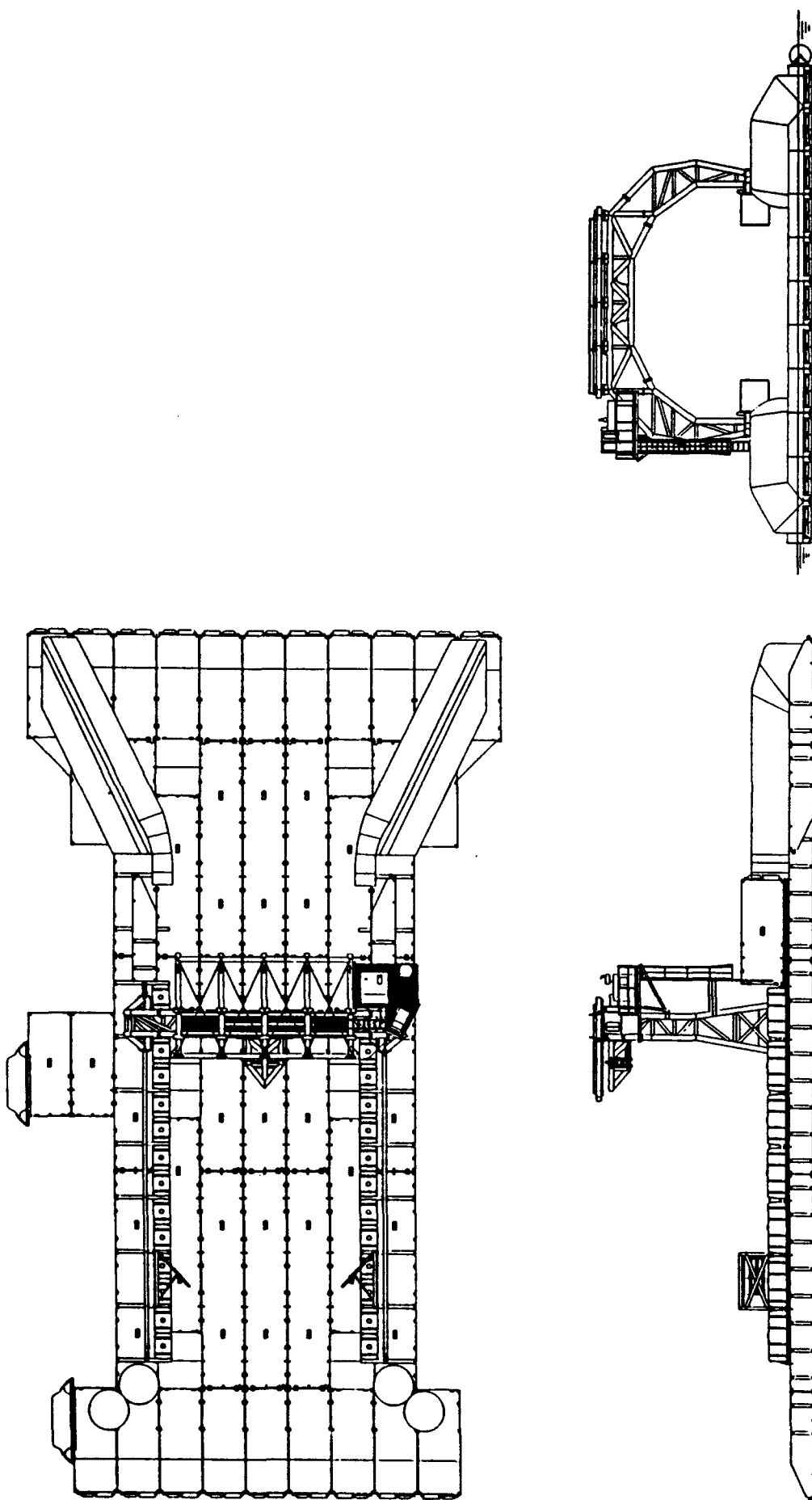


Figure 2. High Sea State Container Transfer System (HISEACOTS)

Section II

PACK Operations

The PACK was assembled at Fort Eustis, VA, 3rd port area, 12-16 August 1991. We connected its modular platform (80 feet long x 32 feet wide) in the water, taking approximately 3 hours, and lifted it onto the hardstand area using the 100-ton capacity barge crane (Photo 1).*

The new PACK system incorporates the following changes from the design tested in 1990.²

- Replacement of bag-to-bag zippers with lacing design
- Reinforcement of finger tails and bag harnesses
- Replacement of aluminum snaps with coated steel threaded fasteners for joining finger tails and harnesses
- Addition of mooring bitts, lockers, non-skid surface, and safety railing for each push knee, and a 20-ton capacity steamboat ratchet for a fourth tie-down point
- Addition of engine enclosures, Foreign Object Damage (FOD) screens, two-part fan duct interface, and internal skid-mounted flexible fuel tanks
- Removal of landing pads
- Improvement of push knee tie-down stud assemblies
- Addition of drain hole patches for corner bag segments
- Addition of closed stern fingers
- Addition of Kevlar towing lines

It took 3 days to install the skirt system (approximately 140 manhours). The coated steel threaded fasteners used to connect skirt fingers and harnesses increased the overall time. (Photos 2 and 3). The new lacing design (Photo 4) was simple to install but slowed the process. It took approximately 1 hour to lace one bag-to-bag joint. However, the push knee installation was very fast and straightforward, taking about 5 minutes apiece to install; and the new steamboat ratchet connection was very easy (Photo 5). The installation of lockers in the push knees (Photo 6) provided ample storage room for tie-down chains, tools, and spares. The installation of the engine-fan units (Photo 7) was also very quick and simple, taking approximately 5 minutes to position and tie-down each. The addition of a two-part duct interface and worm-gear

**Note: Photos 1 through 69 are presented in Appendix A.*

winches made connecting the fan duct relatively easy. We split the duct into two pieces for ease of handling and transportation. The worm-gear winches made it possible for a one-man installation (Photo 8). It took 90 minutes each to install the two-part duct. We sealed the modular platform joints with a commercially available foam. Foaming the entire platform took approximately 3 hours which included drying time. The PACK was lifted into the water, without push knees, using a specially designed lifting sling assembly (Photo 9).

On 19 August, the PACK was towed over water to Fort Story, using an LCU-2000. We attached additional fendering to each push knee before the tow to ensure adequate standoff from the LCU's side hull (Photo 10). At Fort Story, a LARC-LX towed it onto the beach (Photo 11). Then, we loaded it with a 250-ton capacity beach crane weighing 131 tons. The PACK's portable beach ramps were used to upload the crane (Photos 12 and 13). Each beach ramp weighs 12,500 pounds and was emplaced using the Rough Terrain Container Crane (RTCC). A LARC-LX towed the PACK off the beach to an anchored LCU-2000 (Photos 14 and 15). The LCU towed the PACK and crane to Norfolk, VA, where the beach crane was offloaded with a Navy barge crane.

On 23 August, we loaded a D-7 bulldozer, RTCC, and the portable beach ramps onto the PACK (Photos 16 and 17) at Fort Eustis. An LCM-8 towed it from the 3rd port to the James River channel where a pair of LACV-30s took the hand-off (Photos 18 and 19) and pushed the PACK to Anzion Beach, approximately 1 nautical mile (Photos 20 and 21). There, the RTCC offloaded the beach ramps from the PACK, allowing for the discharge of both vehicles (Photos 22, 23, and 24). The D-7 then proceeded to tow the PACK onto the beach.

On 13 September, an LCU-2000 towed the PACK to the Auxiliary Crane Ship (T-ACS)-7 anchored in the James River. The PACK was uploaded onto the T-ACS deck, using a tandem crane lift and spanning hatches 3 and 4, for transport to Fort Story. Both PACK sling assemblies were used for this operation. The fully assembled PACK weighed 115 short tons. To prevent excessive ship roll during the lift, the ship's forward crane was swung outboard on the opposite side of the tandem lift to act as a counterweight. The T-ACS is limited to approximately 3 degrees roll before the ship's crane automatically shuts down. The PACK skirt was inflated during the initial lift from the water to prevent trapping water in it. The skirt was deflated once it was clear of the water surface. Once on deck, the inboard push knees were removed to make room for a Side Loadable Warping Tug (SLWT) that was loaded alongside.

We attempted a PACK offload from the T-ACS at Fort Story, VA, on 15 September. The skirt was damaged when the T-ACS began to swing with the tide, exposing the beam of the ship to some swell. This, in turn, caused the ship to roll. As the ship rolled, the PACK, now hanging from the ship's cranes, began to pendulate excessively. The rider block tagline system was not used during this offload attempt nor were there taglines cleated to the deck. Approximately 20 percent of the PACK's skirt fingers and harnesses were damaged. They snagged on the hatch cover stanchions while swinging across the deck. Repairs used spare fingers and stitching or riveting where necessary. The PACK was successfully offloaded from the T-ACS on 17 September (Photos 25 and 26). The rider block tagline system and cleated taglines were used properly to prevent any further damage to the skirt system. Parts of the skirt were tied up to prevent accidental snagging on the hatch cover stanchions.

On 17 September, a 140-ton capacity beach crane, with base boom section and one counterweight, was loaded onto the PACK (Photo 27). The estimated weight of the basic carrier (with front bumper counterweight) and the "A" counterweight was 58 short tons. Once loaded onto the PACK, the beach crane was driven forward to trim the craft. We used an LCU-2000 to tow the PACK with the beach crane to the Amphibious Discharge Site for transfer to a LARC-LX (Photo 28). The LARC-LX towed the PACK onto the beach for discharge (Photo 29). The LARC-LX experienced some difficulty while continuing to tow the PACK inland to the desired offload site. The PACK skirt system was not sealing properly and the craft was not trim. It is estimated that two complete fingers were missing and approximately 20 air gaps in the finger harnesses significantly reduced the hover height which was exaggerated by the uneven trim condition. However, despite this air loss and trim condition, the LARC-LX was able to pull the PACK to the beach for discharge and further inland to the crane discharge site. The 140-ton capacity beach crane (with outriggers) was offloaded using the PACK's portable beach ramps (Photo 30). Repairs were completed on the beach using old PACK skirt fingers and stitching and riveting where required.

The PACK continued to demonstrate its heavy lift capability during the J-LOTS III exercise. Other vehicles carried by the PACK included: two M1A1 tanks (128 tons); one RTCC with ramps (64 tons); and one RTCC with D-7 bulldozer and PACK beach ramps (90 tons) (Photos 31 and 32).

On 25 September, The US Navy Landing Craft Air Cushion (LCAC) towed the PACK, which was loaded with the RTCC, D-7 bulldozer, and beach ramps (Photos 33 and 34). The LCAC was moored beam-on to the PACK for the demonstration. It produced a large amount of spray during the tow and maintained a much higher cushion flow rate than necessary. As a result, the LCAC produced excessive amounts of spray that collected on the deck of the PACK. The PACK had to be brought off-cushion once in order to drain off the water. The LCAC operator was not trained for this type of mission and was very slow and deliberate when maneuvering the PACK. The LCAC pushed the PACK at about 3 to 4 knots. In addition, communication with the LCAC operators from the PACK deck, using hand-held marine radios, was very difficult because of high noise levels.

On 26 September, the PACK was towed back to Fort Eustis by a Small Tug for disassembly. The PACK's skirt drain patches were used to help drain water that was caught in the corner bag segments while the PACK was lifted from the water (Photo 35).

Section III

HISEACOTS Operation

The HISEACOTS was assembled 26 August - 6 September at Fort Eustis' 3rd port. An assembly schedule with assembly sequences is provided in Appendix B. HISEACOTS equipment that was previously stored on a cargo barge was offloaded by the 100-ton capacity barge crane. Changes and hardware additions incorporated into the HISEACOTS design subsequent to the calm water tests in April 1990 included:

- Steel beam traversing rails and gantry crane foot pad carriage assemblies with disk brakes
- Fiberglass water tank batterboards
- Bolt-on arresting gates
- A gantry crane winch and carriage assembly and chain
- Exit ramp polyethylene ballast tanks
- Half-inch Ultra High Molecular Weight (UHMW) wearboards

We completed the HISEACOTS platform assembly in 5 days (approximately 180 manhours). Installation of the approach batterboards was faster and easier than the previous set-up during the calm water test because we installed approach batterboard water bladders as a unit rather than individually (Photos 36 and 37). A steel "A" frame with chain fall proved helpful in the installation of the batterboards and steel rails. PVC fill valves were installed on the tops of most of the approach batterboard water bladders to purge any trapped air and provide an easily accessible spot to top off the tanks in case of leaks (Photo 38). Several small leaks were found in those bladders that had been repaired. They were caused by cuts made to help drain the lower portions of the bladders after the calm water tests. Threaded valve patch assemblies were cold bonded over the cuts to simplify future draining operations. Four 1/2-inch thick UHMW transition wearboards were installed adjacent to the 1/4-inch wearboards on each side of the approach batterboards to help protect the aftmost stack of fiberglass water tanks (Photo 39).

Installation of the gantry crane rails was straightforward. Transverse steel I-beams (W 10X45) were bolted to Robishaw turn-tube cleats that were fastened to the deck on both sides of the platform. Longitudinal steel I-beams (W 10X45) were then bolted to the transverse beams. I-beam rail supports were bolted underneath these longitudinal members at mid span to help

prevent excessive rail deflection (Photo 40). Two chain stanchions were bolted to each end of the port side rail track; and gantry crane stops were installed port and starboard with set screws on each end of the gantry rail (Photo 41).

We installed the gantry crane carriage assembly on-site. It involved bolting three dolly rollers to a carriage running along the top flange and web of the I-beam. The carriage has threaded studs on the top plate to secure the gantry crane feet (Photos 42 and 43). Two heavy-duty disk brakes were fitted onto the forward carriage assemblies (Photo 44), and we lifted the gantry crane onto the carriage assemblies and bolted it down without difficulty.

The gantry crane winch/hydraulic carriage was installed between the port side gantry crane feet (Photo 45). It was awkward plumbing the hydraulic hoses, but it did not interfere with the traversing capability (Photo 46). A 70-foot long load chain connected to the aft chain stanchion was threaded through the carriage chain sprockets and finally attached to the forward chain stanchion (Photo 47).

Two arresting gates (8.5 feet high x 10.5 feet wide) were bolted to transverse rails on both sides of the platform (Photo 48). The gates are passively operated by a self-contained hydraulic system (Photo 49). The gates position the LACV-30 and stop it when a container is prepositioned on the gantry's spar. The gates are normally in an extended position unless closed by an LACV-30 high pressure fender. (Photo 50) Return springs open the gates to their fully extended position (Photo 51).

Fiberglass water tanks (38-inch diameter x 250-gallon capacity and 48-inch diameter x 800-gallon capacity) were installed inboard of the gantry crane on each side of the platform. Steel pipes (2.5-inch diameter, schedule 80), installed along the entire length of the rail assembly, cradled the tanks into position. Steel strap retainers fastened the tanks to these steel pipes (Photo 52). The 800-gallon tanks were stacked in a 1x2x3 configuration just forward of the approach batterboards to help position the LACV-30 in a "worst case" fly-on approach (Photo 53).

Dock-side fly-on/fly-off training at Fort Eustis was conducted on 6 September (Photo 54). The arresting gates worked well interfacing with the LACV-30's high pressure fenders (Photo 55). Adjustments had to be made to the flow control valve in order to increase the gate's resistance. The gates are designed to stop an LACV-30 traveling around 3 to 4 knots. The LACV-30s did not

have any problems opening the gates to fly-off the platform (Photo 56). The steel straps used to tie-down the fiberglass tanks produced some rips on both sides of the LACV-30's bag. This was attributed to the straps snagging the LACV-30's external fasteners. All the straps securing the tanks were removed. It was felt that the weight alone in each tank was sufficient to keep them in their cradles. Damage was inflicted to the starboard side 800-gallon tanks (Photo 57) by an LACV-30's hardstructure when attempting a fly-on. These 800-gallon tanks were eventually replaced with a 20-foot raked end ISOLOG module that was placed on its side on both sides of the platform. The modules were chained down to the deck and gantry crane transverse rails to prevent tipping if hit by the LACV-30 (Photo 58). The 1/2-inch UHMW wearboards were tied back to the steel pipes to help protect the ends of the approach batterboards and also to help guide the LACV-30 onto the platform (Photo 59).

An Army Large Tug towed the HISEACOTS to Little Creek, VA, on 11 September (Photos 60 and 61). The tow took 10 hours. In case of emergency, an Army Small Tug was dispatched. Two Army Side Loadable Warping Tugs (SLWTs) docked the HISEACOTS temporarily in Desert Cove.

On 19 September, the HISEACOTS was towed to the T-ACS ship anchored off of Fort Story and moored. Mooring took approximately 4 hours. The Army's Large Tug, Small Tug, and SLWTs helped in the platform tie-up (Photo 62). The HISEACOTS was moored aft of station 130 at the stern end of the T-ACS (Photos 63 and 64). The LACV-30 completed four fly-on/fly-off operations before a severe storm late in the afternoon forced the exercise to shut down (Photo 65). No container transfer operations were attempted before the storm hit. The storm lasted approximately 36 hours and generated a sea state 4 (5 to 7 feet wave heights) according to the J-LOTS test directorate. A majority of the J-LOTS equipment, including the HISEACOTS, was damaged. The entire exit ramp string broke away from the HISEACOTS' main platform at 0715 on 20 September. The ISO corner connectors that attached the inverted raked-end ISOLOG modules to the square-end modules all failed (Photos 66 and 67). This can be attributed to two sources:

- (1) the use of lesser strength grade 2 steel nuts to fasten onto high strength grade 8 studs; and
- (2) poor mooring and fendering design which concentrates loads on the ramp module connectors.

A materials analysis of the failed ramp connectors is presented in Appendix C. The analysis indicates that the nuts used to fasten the ramp connectors together were not grade 8 (150,000 B.S.) like the connector studs, but were grade 2 (100,000 B.S.). The analysis also indicates extensive wear to the nuts, as if they may have been stripped from the studs. Also contributing to this failure was the forward fendering and mooring arrangement which, in all likelihood, concentrated loads on the ramp connectors. An analysis of the ramp-joint mechanical failure is presented in Appendix D.

Because the platform, now pivoting on one fender, could damage the T-ACS rudder and propeller, the HISEACOTS was cut loose to ground itself off the beach at Fort Story (Photo 68). A large portion of the platform modules' structural damage was caused by the Army Large Tug continually striking the platform as it attempted to retrieve a line to pull the HISEACOTS away from the side of the T-ACS ship (Photo 69). The HISEACOTS was towed back to the 3rd port at Fort Eustis, VA, on 24 September.

Section IV

Conclusions

PACK

The PACK performed remarkably well as a heavy-lift lighter during the J-LOTS operation. Improvements incorporated into the skirt design before the test greatly improved its durability. The skirt's lacing design proved a rugged and effective method of joining and sealing bag segments. Also, the steel fasteners and aluminum connector plates used to connect the skirt components proved reliable. Consideration should be given to fabricating these fasteners out of stainless steel to avoid corrosion. The PACK's engine enclosures provided protection from cushion spray and also reduced airborne noise. The engine manifolds should be lagged to reduce engine overheating. The flexible fuel tanks leaked fuel into the spill compartment throughout the exercise due to several loose valve fittings. Installing hard tanks rather than flexible ones would correct this. The closed stern fingers allowed the PACK to be towed at higher speeds without significant water scooping. The portable beach ramps worked well in offloading tracked/wheeled vehicles from the PACK. The steel ramps were considered too heavy and should be made lighter to facilitate installation by other materials handling equipment (MHE) including the RTCC.

The PACK demonstrated sealift transportable when fully assembled aboard the T-ACS vessel. This capability provides tactical advantage to the Deployment Commander. However, to improve deployability and reduce the chances of damaging the skirt, a tie-up or brailing system needs to be designed and fielded with the item.

The PACK as a "lighter" proved effective when transporting the Army's 140-ton capacity beach crane to the shore. The PACK also demonstrated the capability to carry other critical beach support equipment such as the Rough Terrain Container Crane (RTCC) and the D-7 bulldozer as well as two M1A1 tanks weighing 64 tons apiece. Finally, the PACK transported the Army's heaviest beach support item, the 250-ton capacity beach crane, from Fort Story to Norfolk, VA.

The LARC-LX proved to be the most effective amphibious prime mover overwater and overland. The LACV-30 pushed the PACK carrying a 90-ton load at approximately 3 to 4 knots and maneuvered it alongside an LCU-2000

for handoff. The ability of the LACV-30 to tow a fully loaded PACK in elevated sea states is still unknown. The LCU-2000 appears to be the best vessel for mooring the PACK next to the T-ACS ship for load-on operations because of its excellent maneuverability, and it is the best vessel for towing in long transits because of its high tow speed. Additional testing should be pursued to show the utility of a Navy LCAC in a stern tow configuration. The Small Tug is capable of long distance PACK stern tows. Beach support equipment such as the RTCC and the D-7 bulldozer make highly effective prime movers overland.

HISEACOTS

Since the HISEACOTS was damaged during the J-LOTS III exercise, the system remains unproven in elevated sea conditions. The modular fly-on/fly-off platform has been shown to significantly reduce the LACV-30's approach and moor and cast-off and clear times next to a T-ACS vessel.³ The platform also reduces the likelihood of damaging the LACV-30's propellers when mooring in high sea states.

An analysis of the HISEACOTS ramp-joint failure is presented in Appendices C and D. The lack of precise sea state measurements during the storm complicates the evaluation of the joint failure. It is likely that a combination of poor fendering and mooring design and the use of lower strength, grade 2 nuts contributed to the joint failure. The HISEACOTS' ramp connection must be redesigned to allow sea state 4 (5 to 7.5 foot waves) and sea state 6 (14 to 20 foot waves) survival when anchored away from the T-ACS vessel. The fendering and mooring must also be redesigned to these sea state conditions.

References

1. **Requirements Analysis for the Lighter, Amphibian (LAMP-H), Naval Coastal Systems Center, November 1987.**
2. **Pontoon Air Cushion Kit (PACK) Concept Evaluation Program (CEP) Technical Report, USA-BRDEC-TR//2503, Belvoir Research, Development and Engineering Center, Fort Belvoir, VA, January 1991.**
3. **High Sea State Container Transfer System (HISEACOTS) Concept Evaluation Program (CEP) Technical Test Report, USA-BRDEC//2515, Belvoir Research, Development and Engineering Center, Fort Belvoir, VA, September 1991.**

Appendix A

Photographs

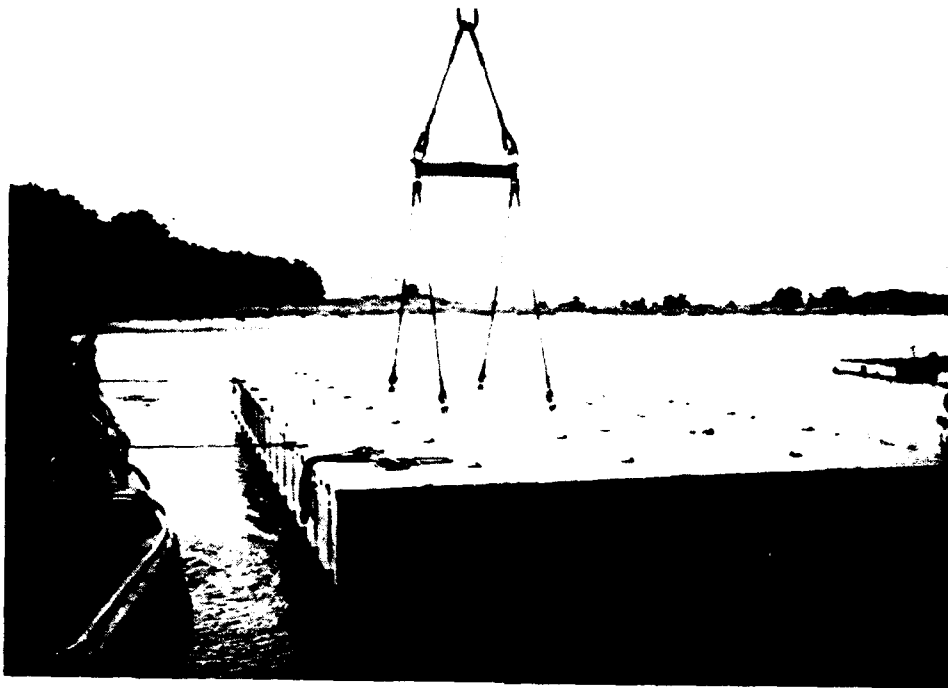


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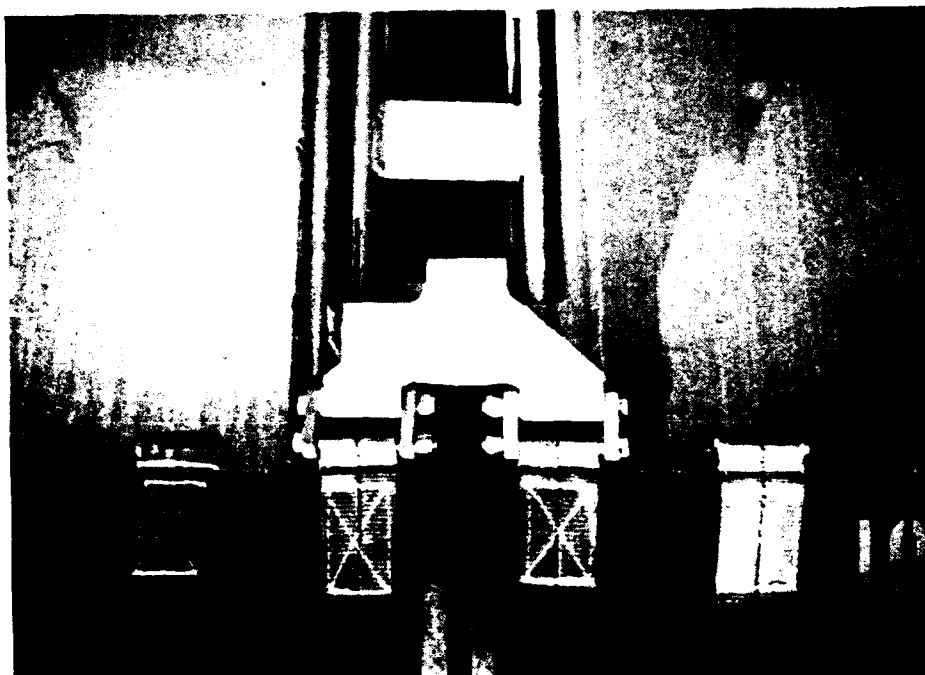


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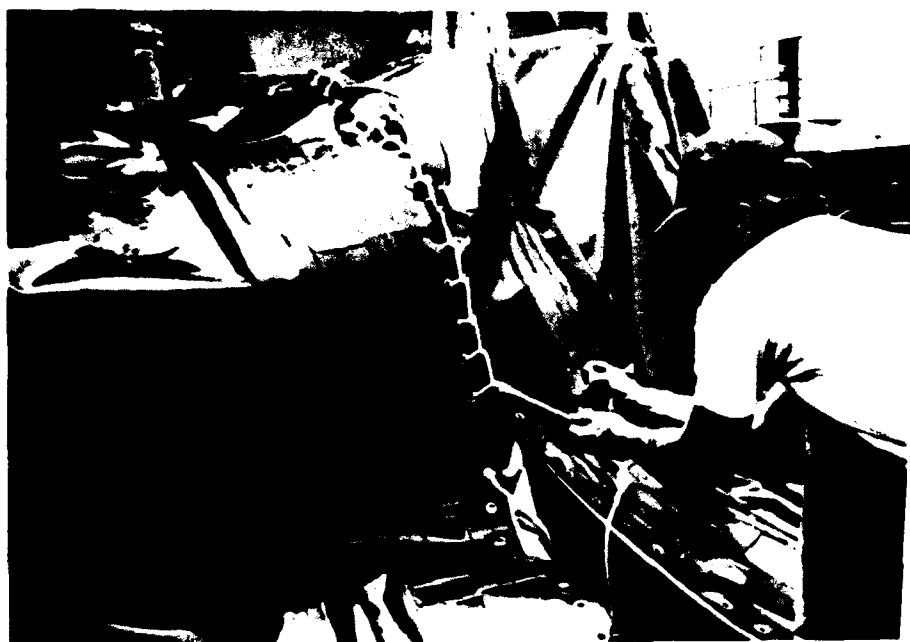


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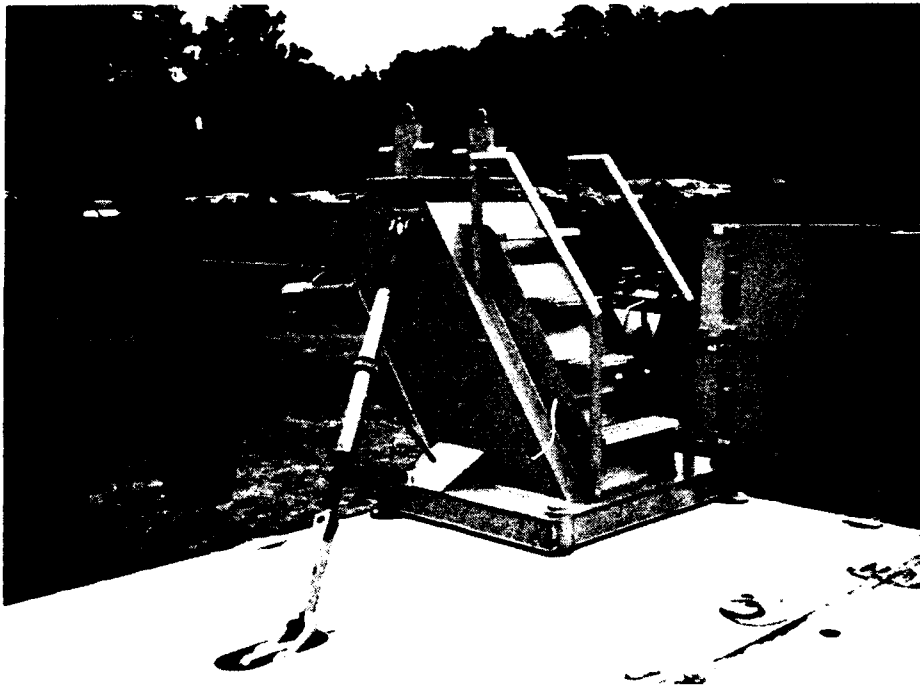


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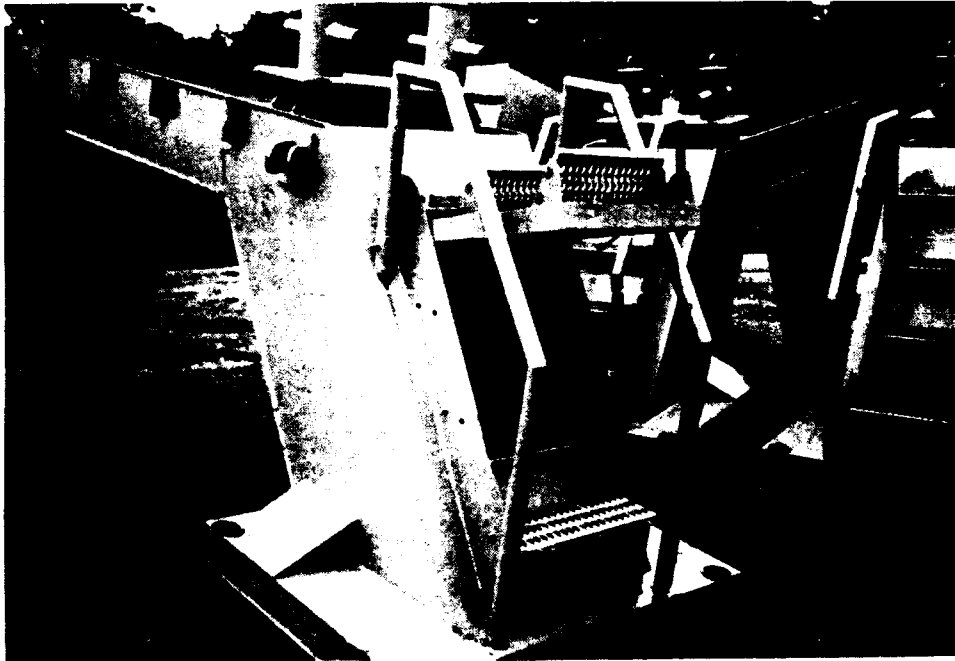


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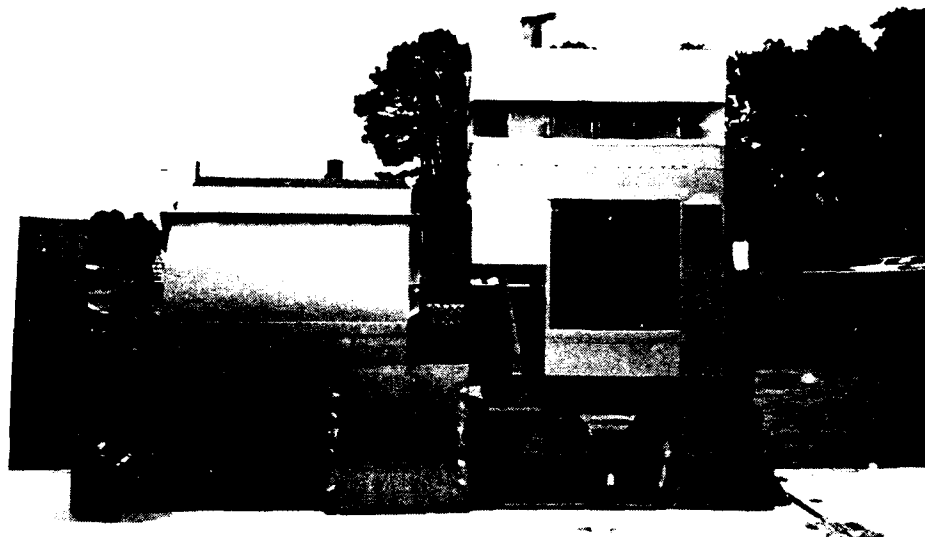


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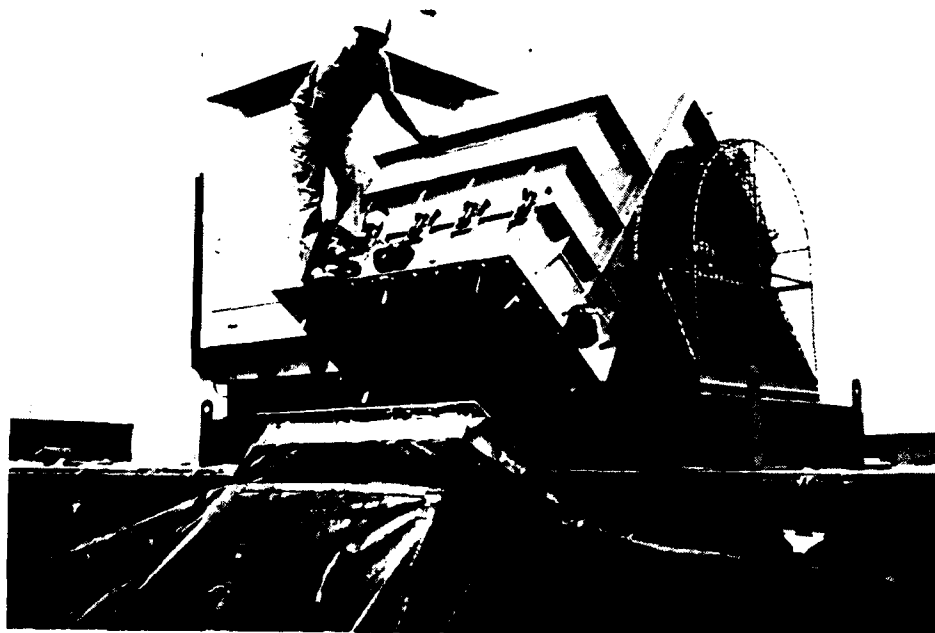


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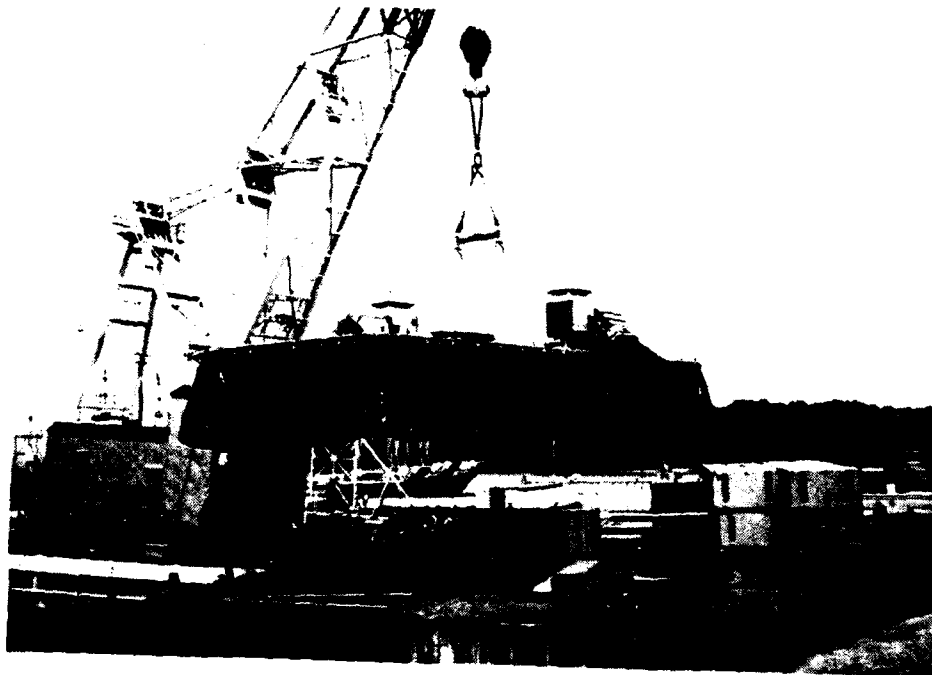


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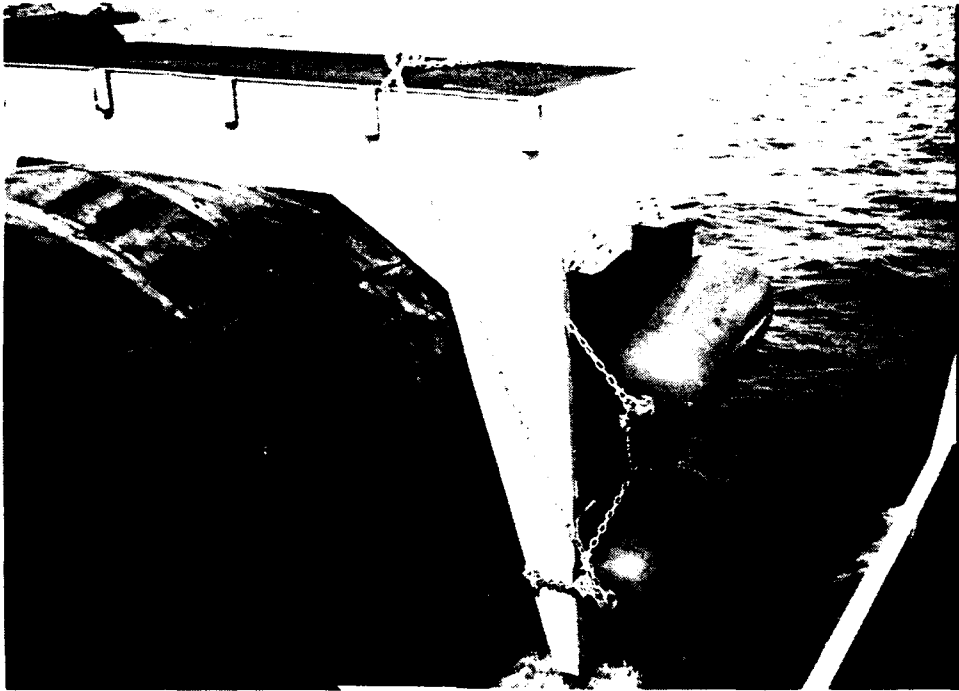


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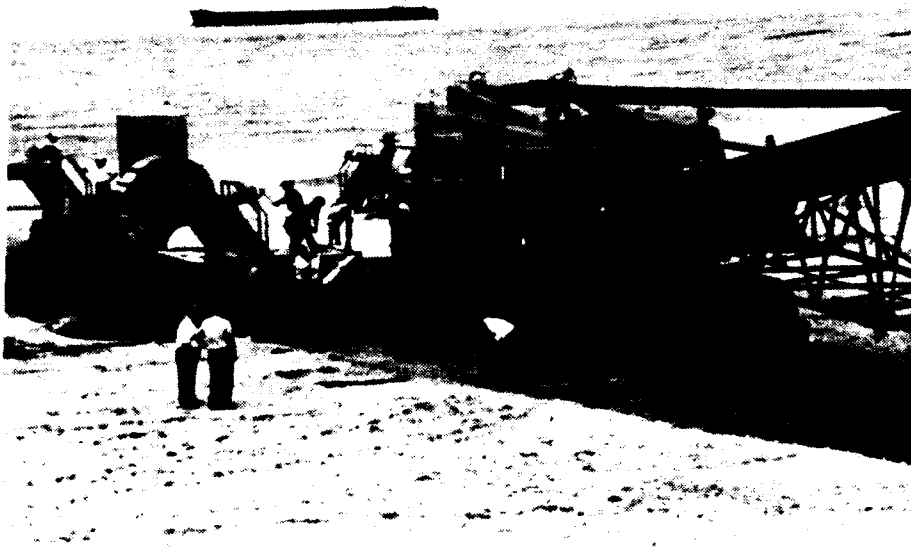


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Photo 13



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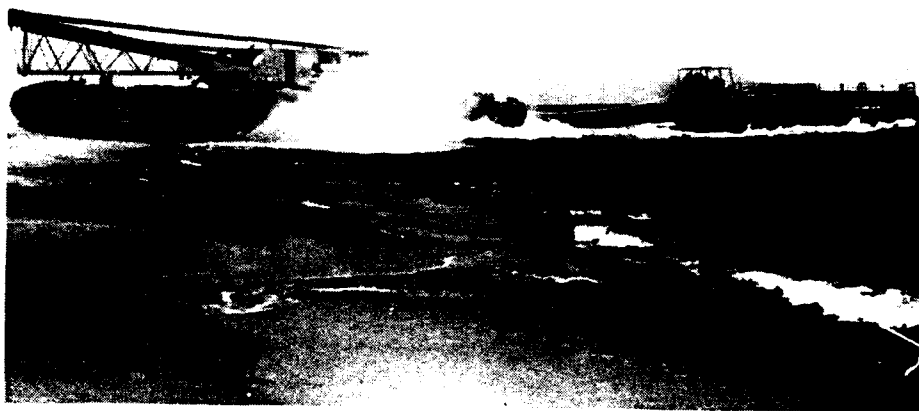


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Photo 16



Photo 17



Photo 18



Photo 19

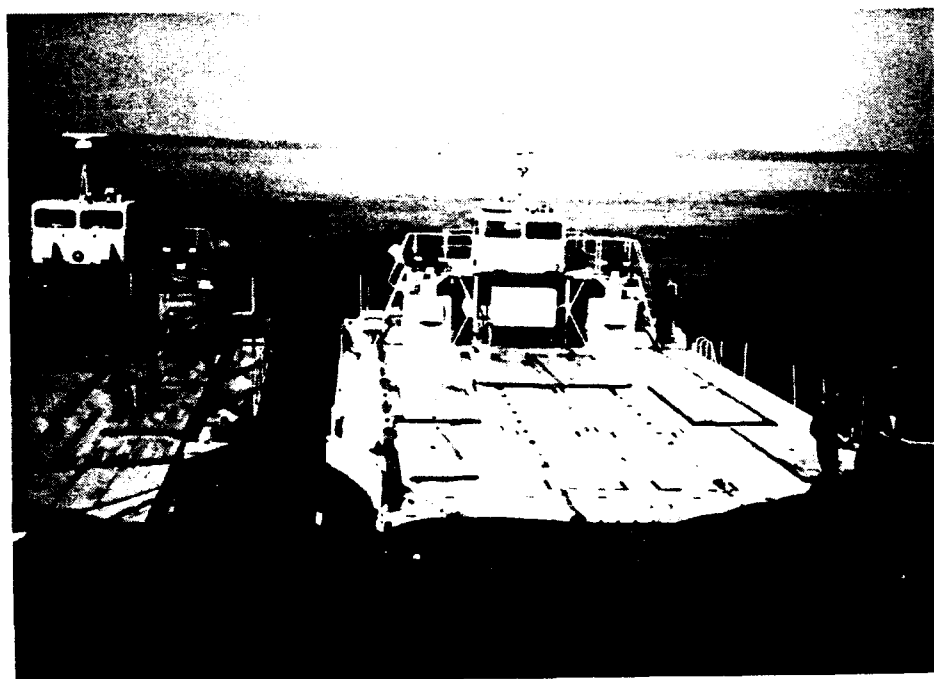


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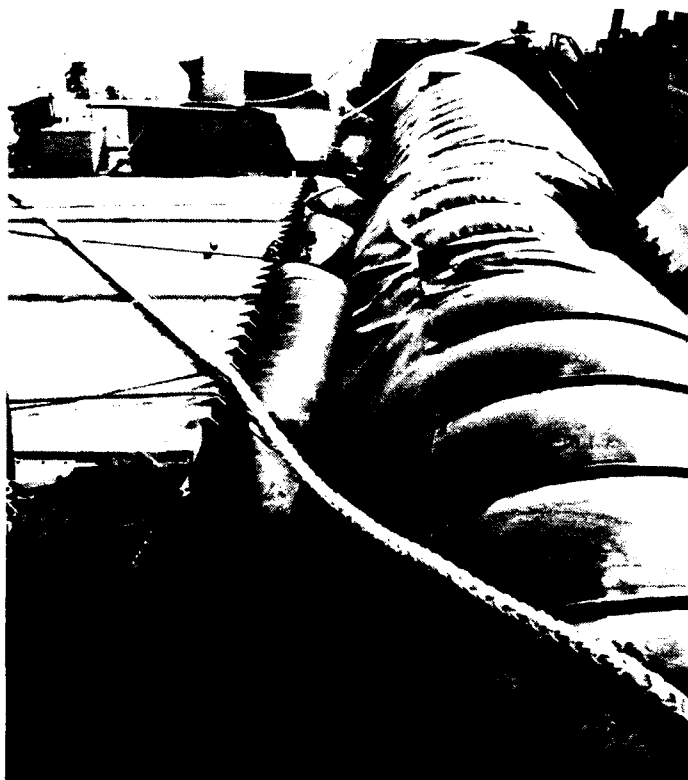


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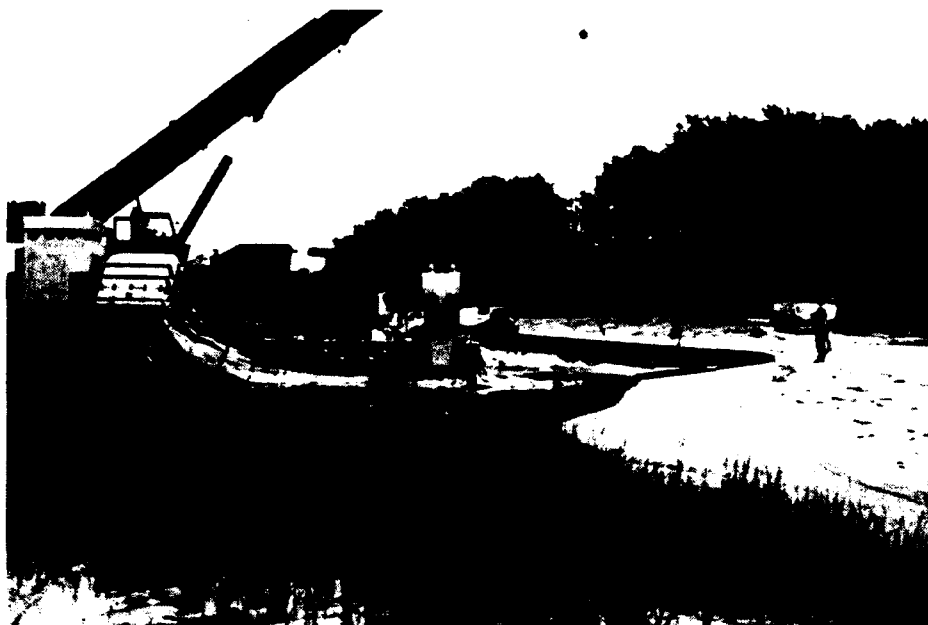


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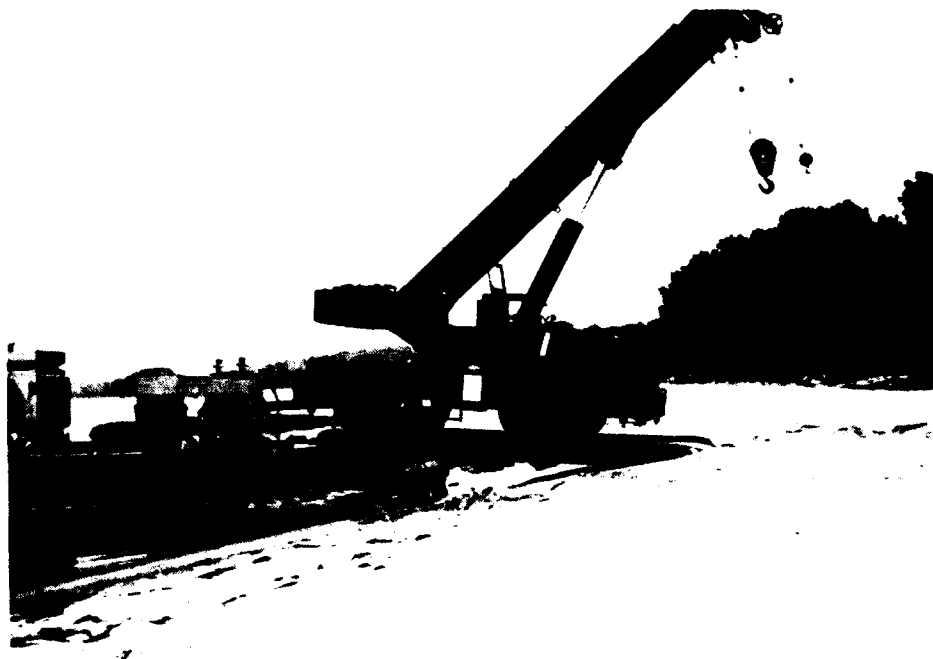


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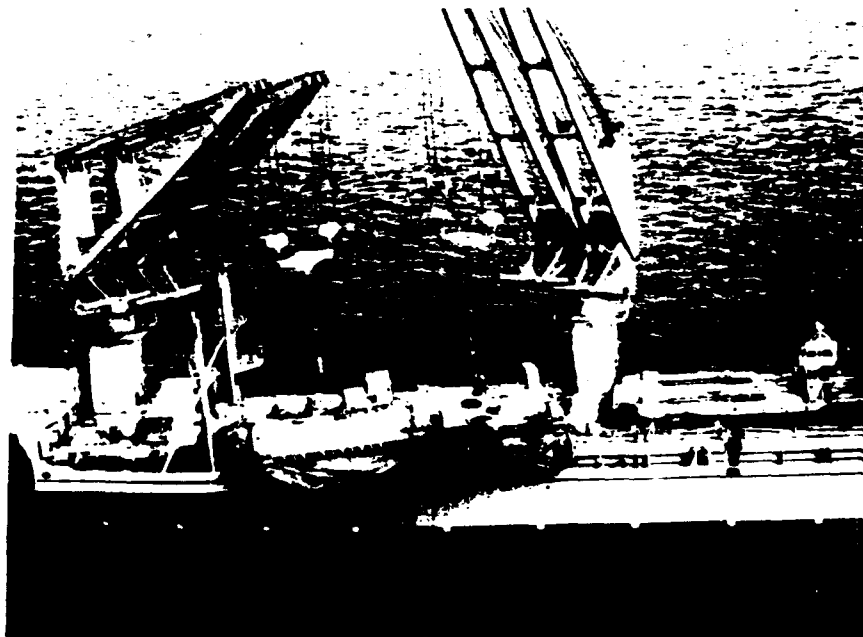


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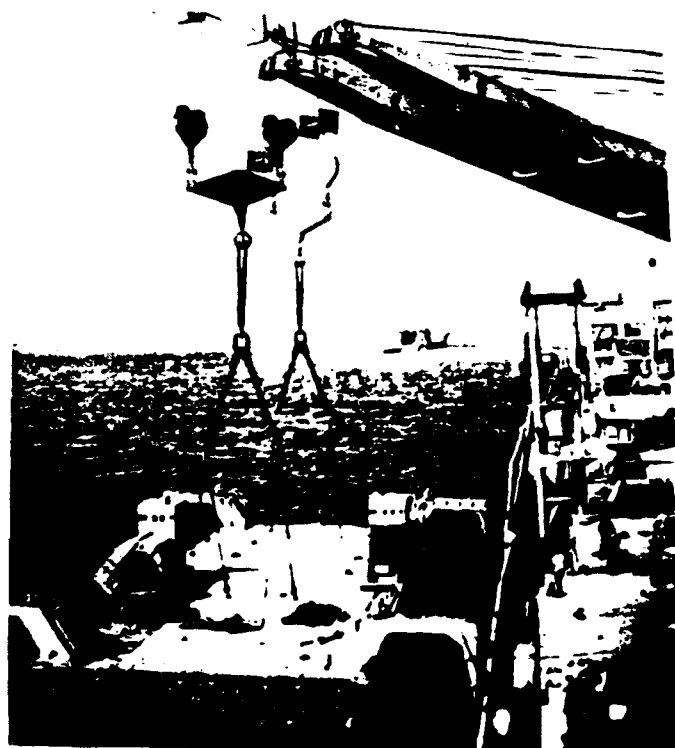


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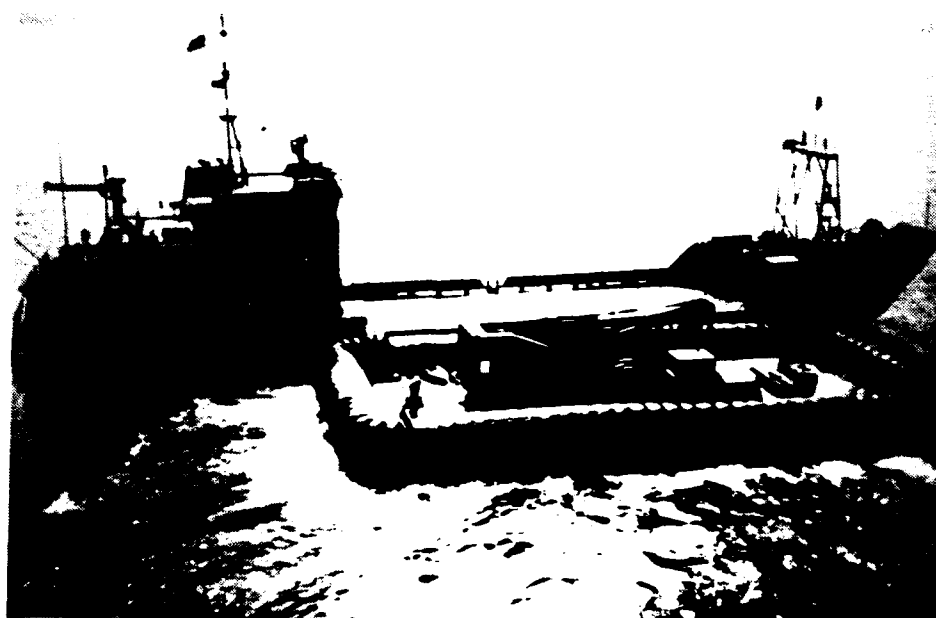


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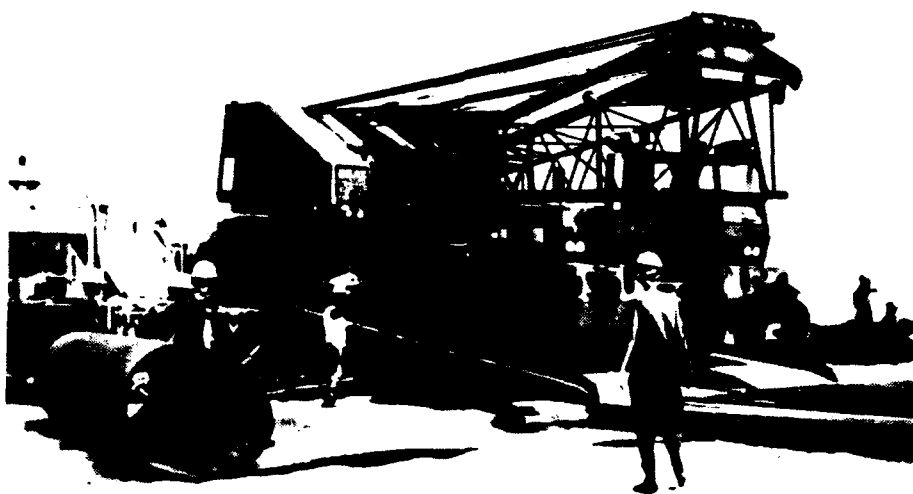


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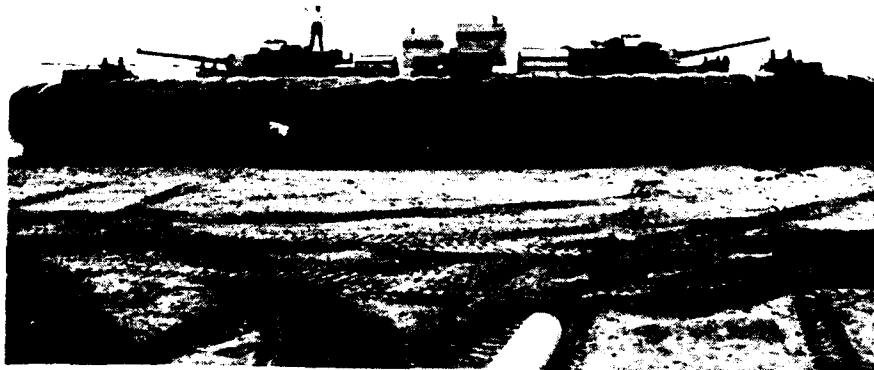


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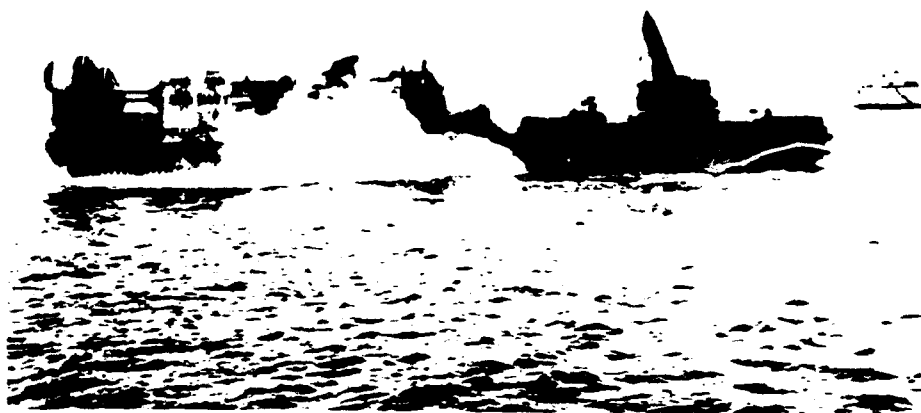


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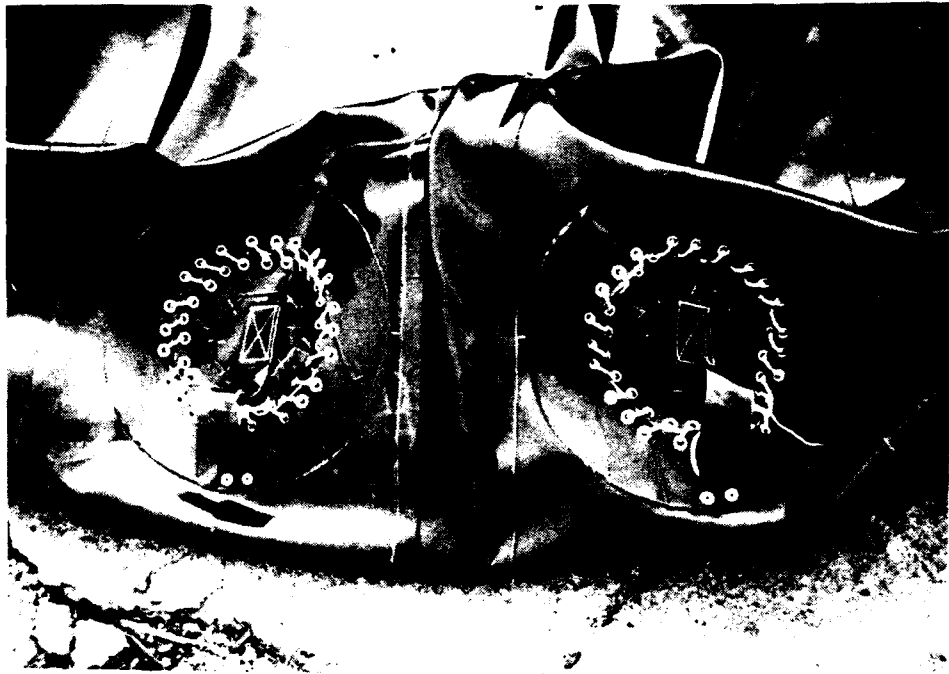


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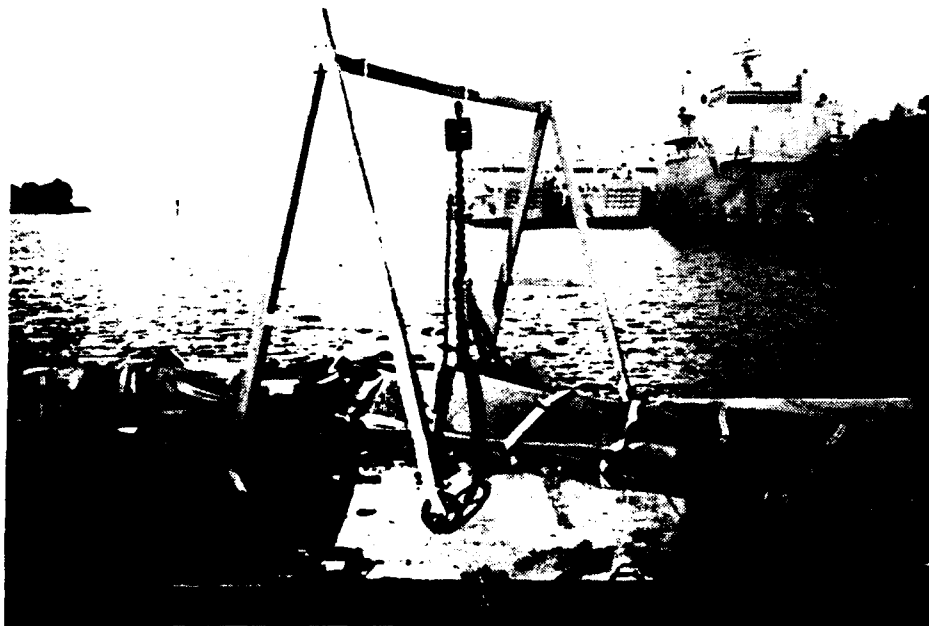


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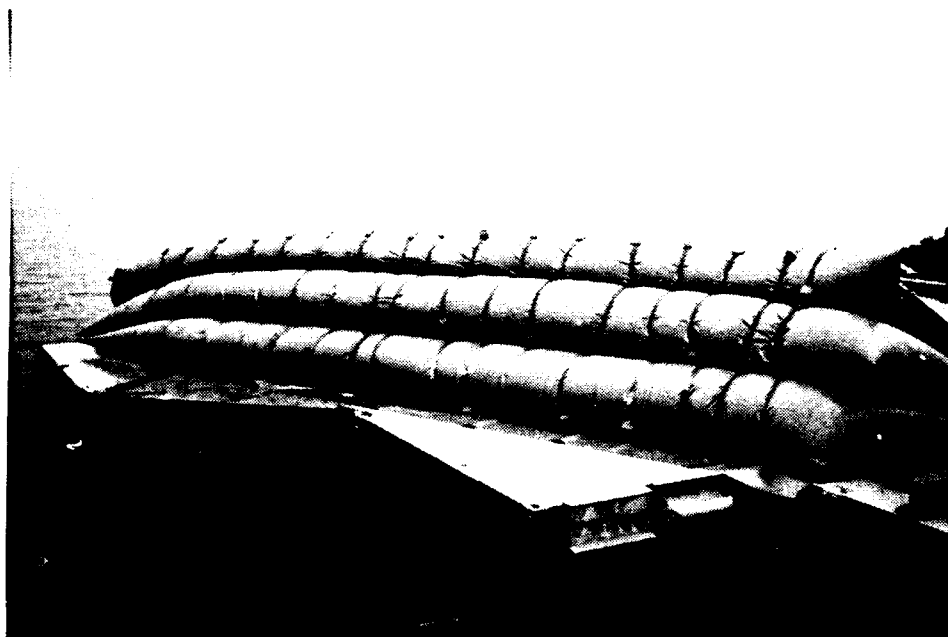


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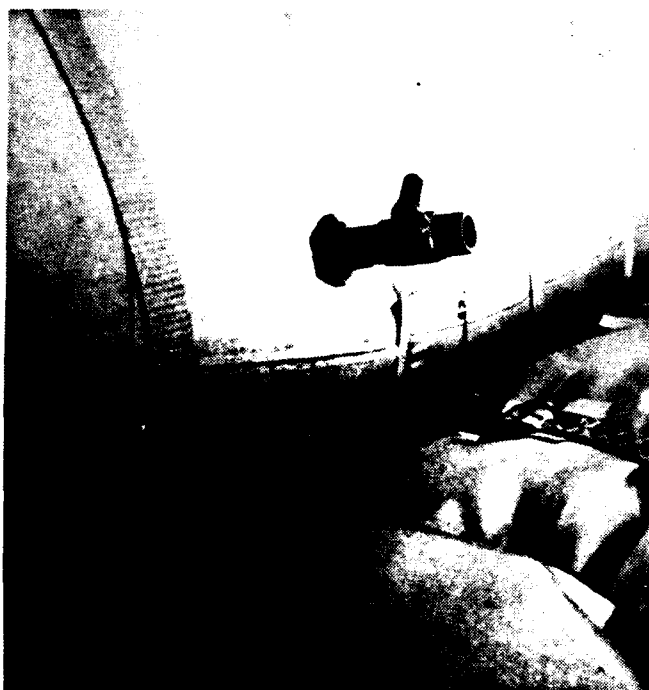


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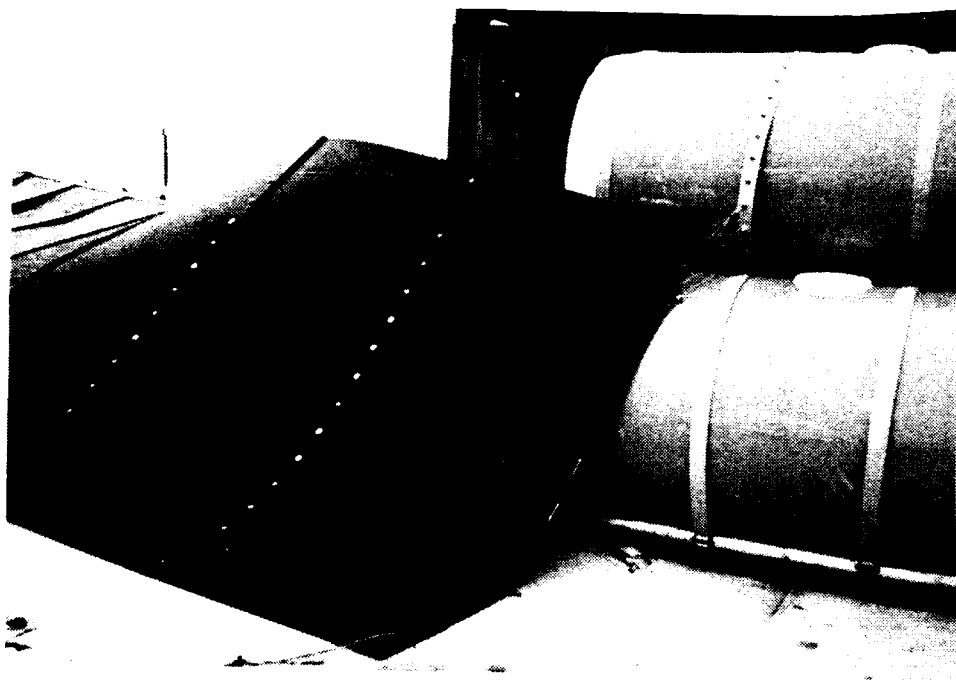


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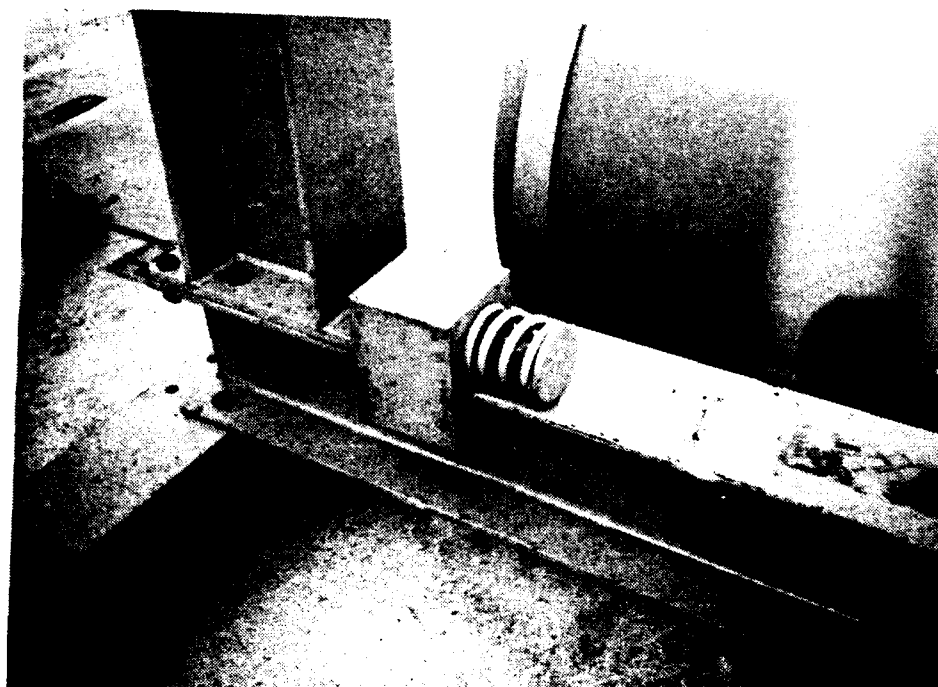


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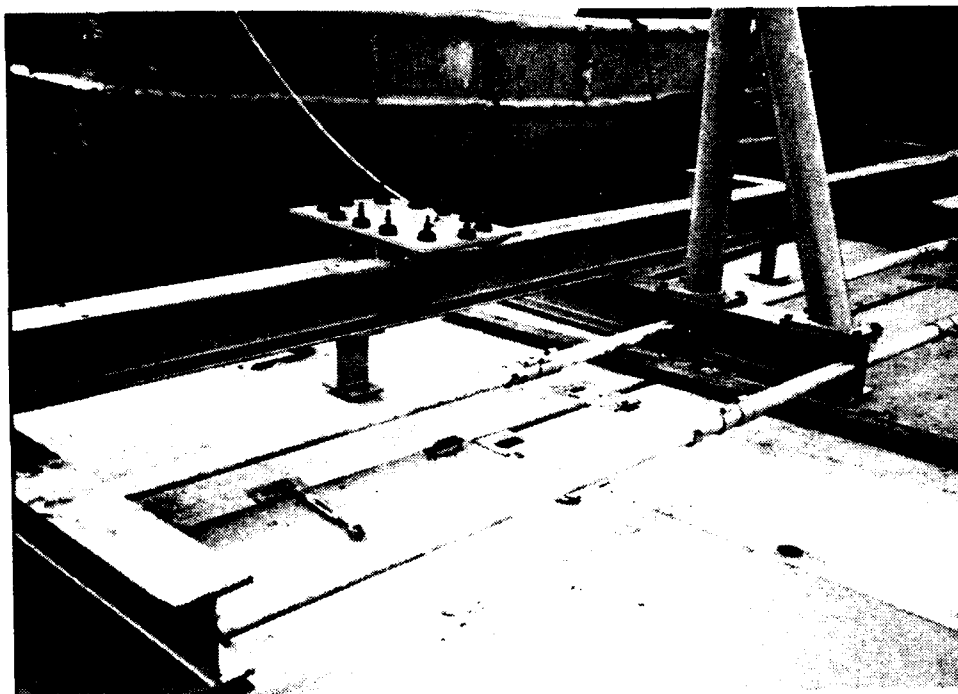


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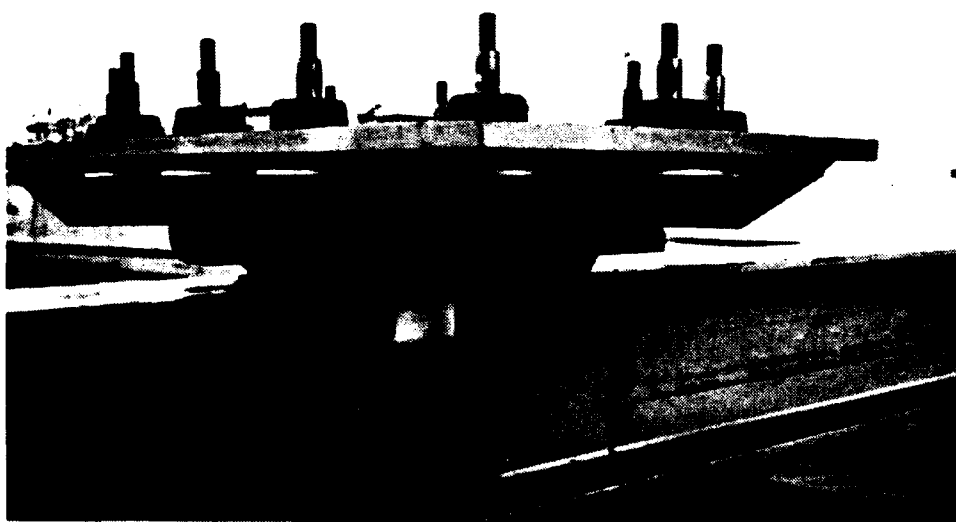


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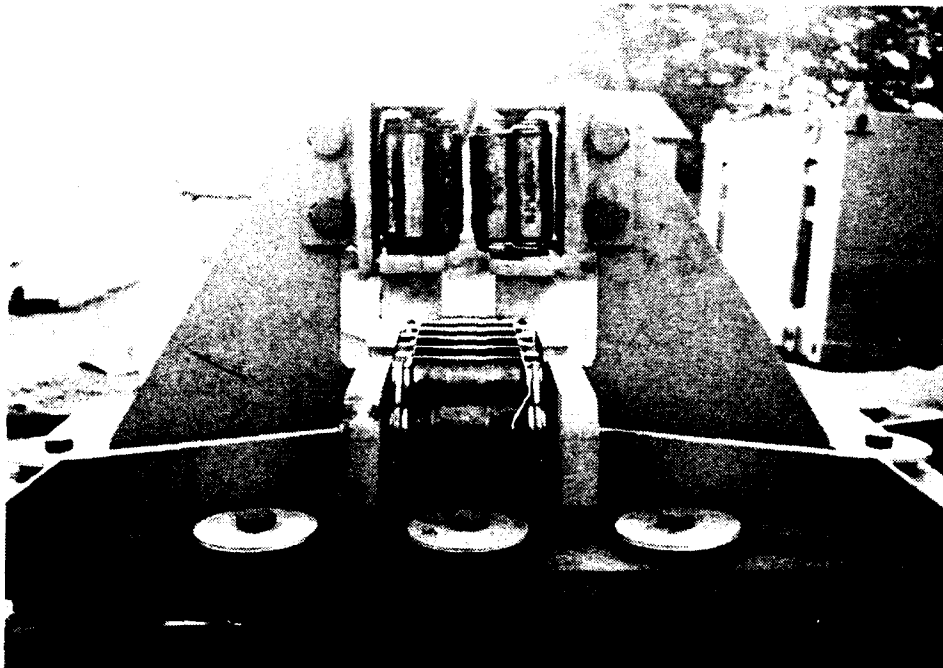


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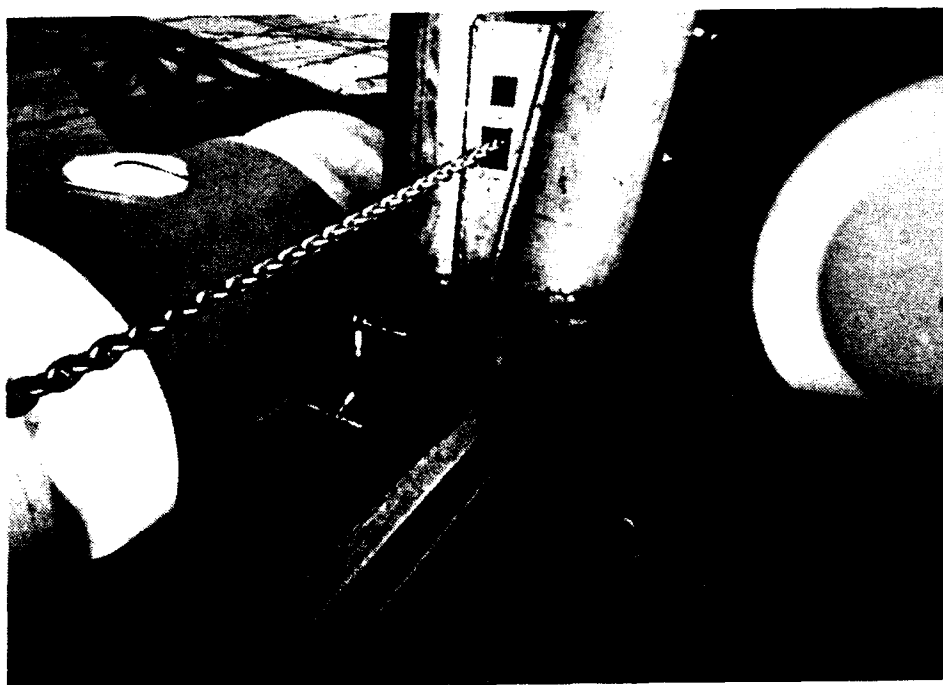


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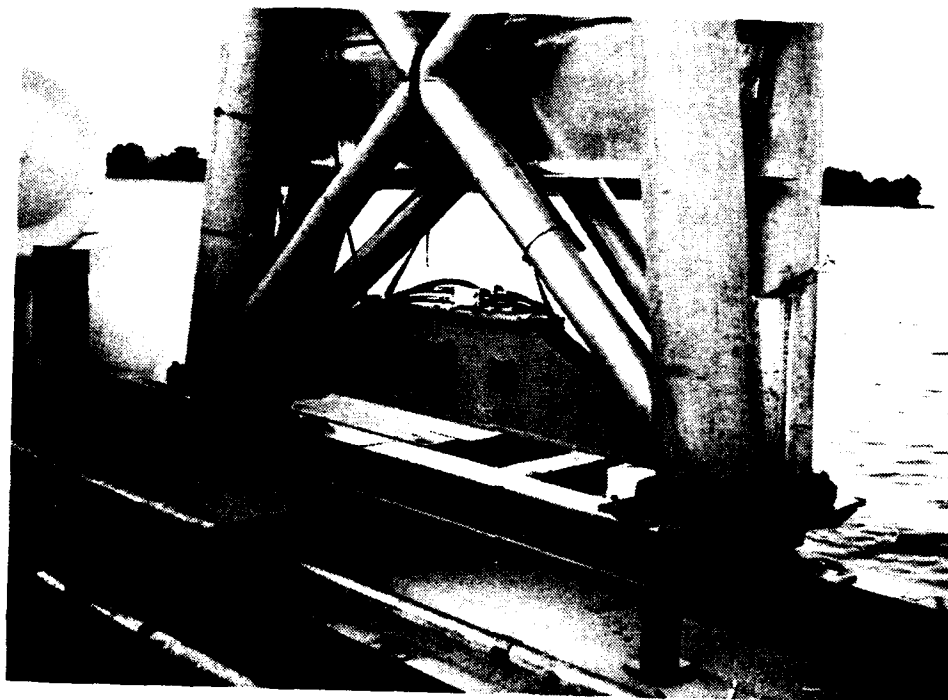


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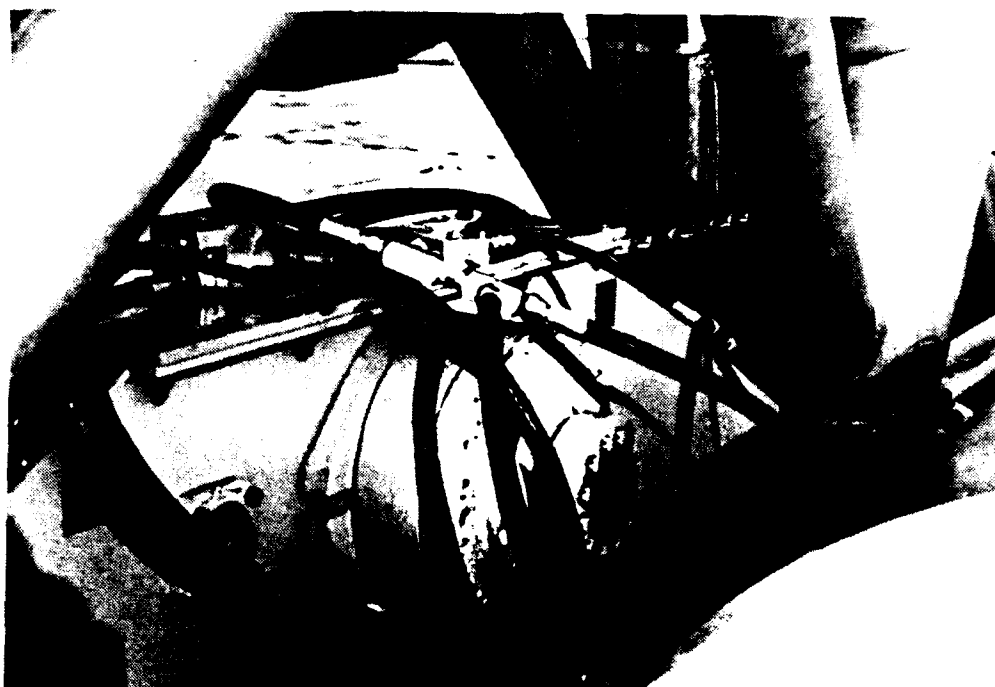


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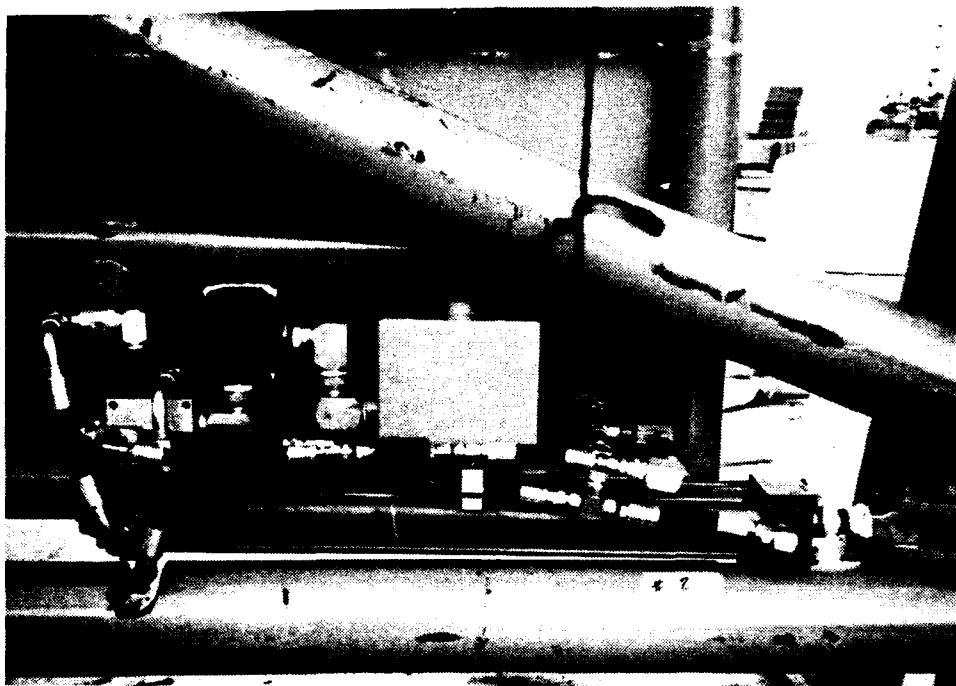


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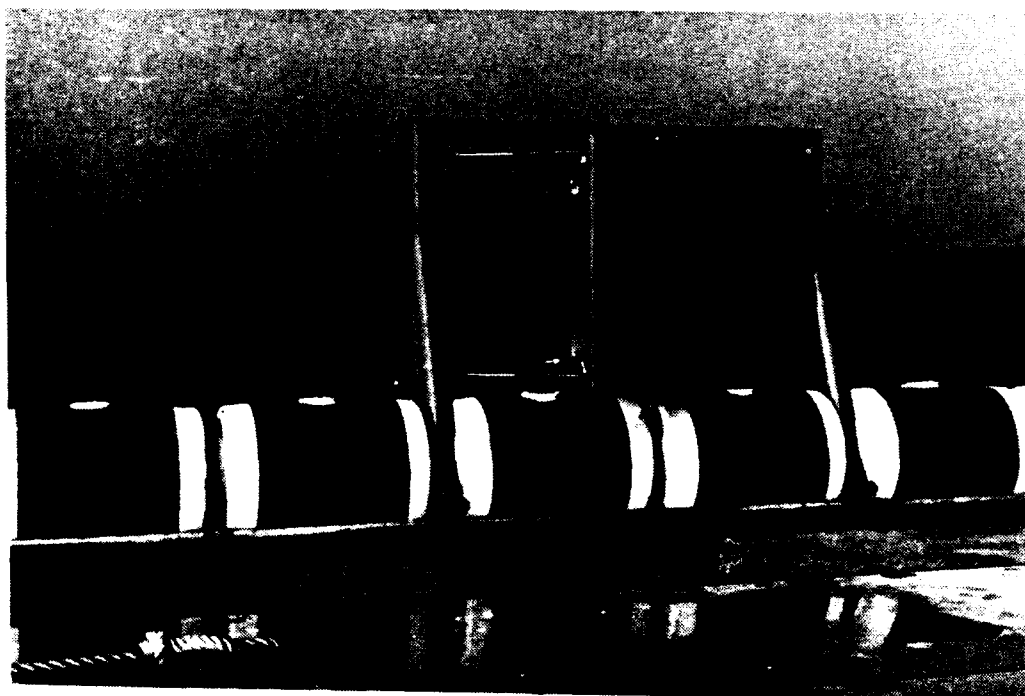


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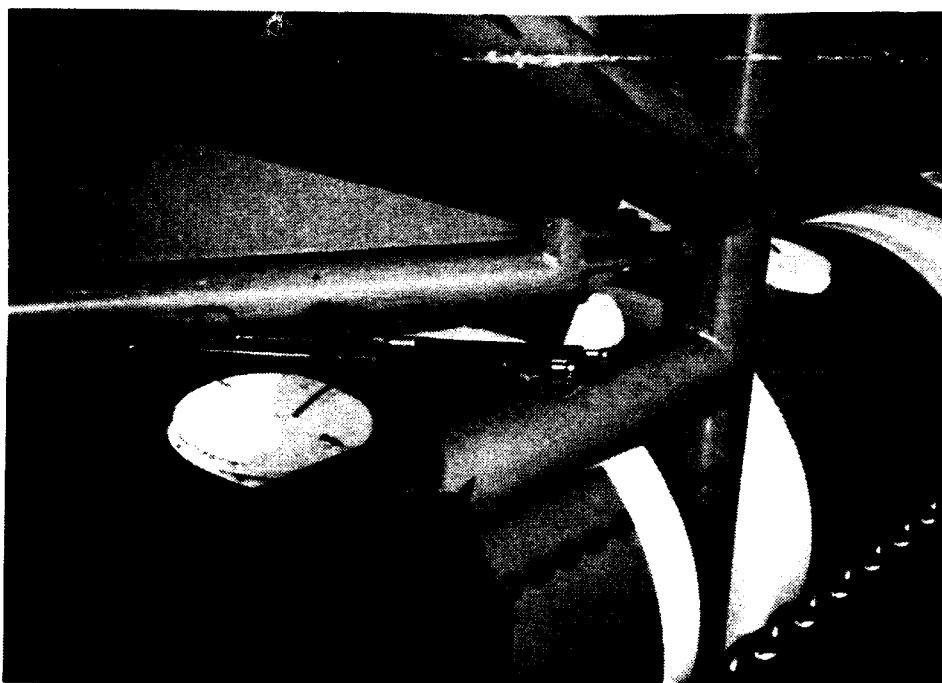


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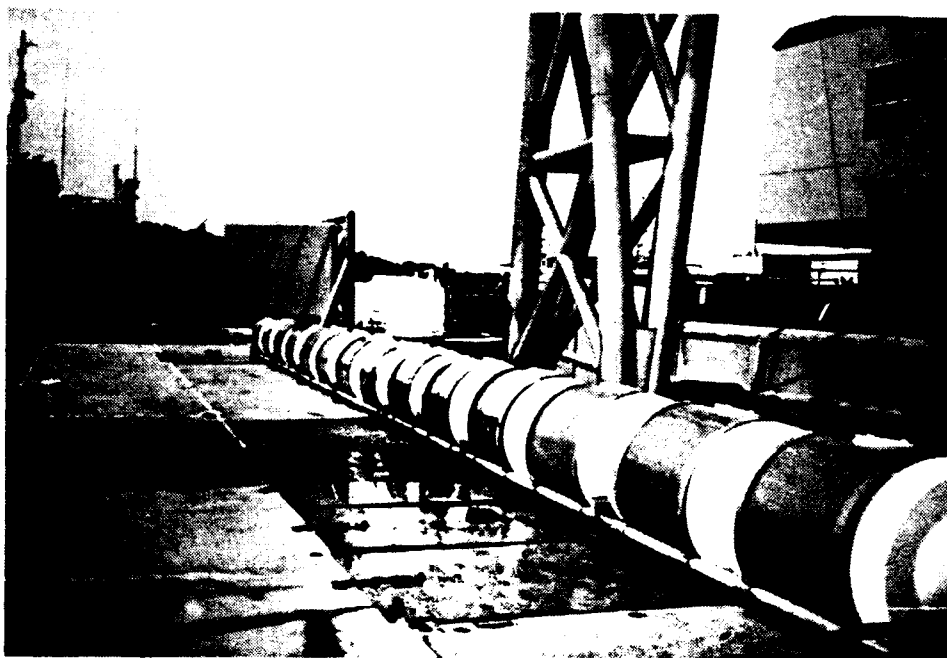


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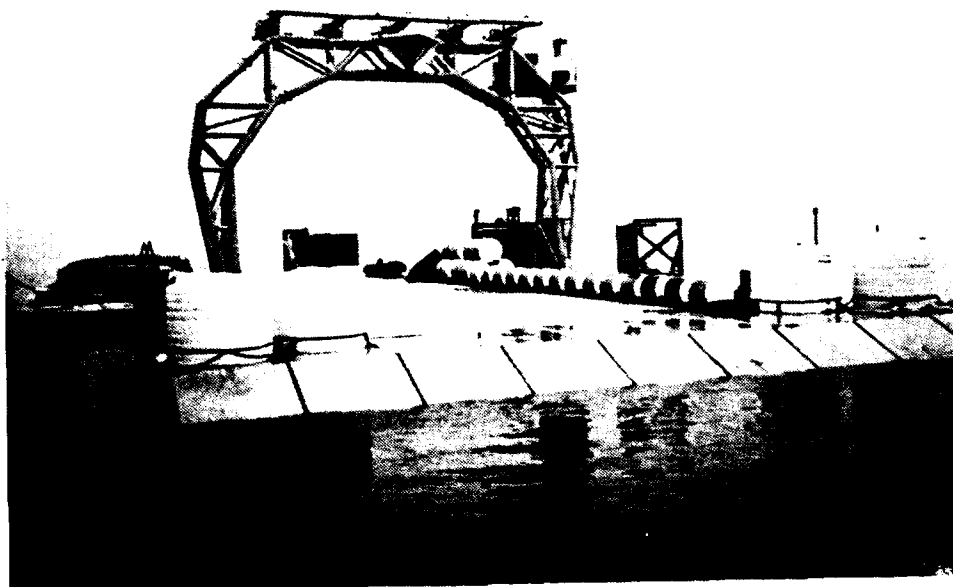


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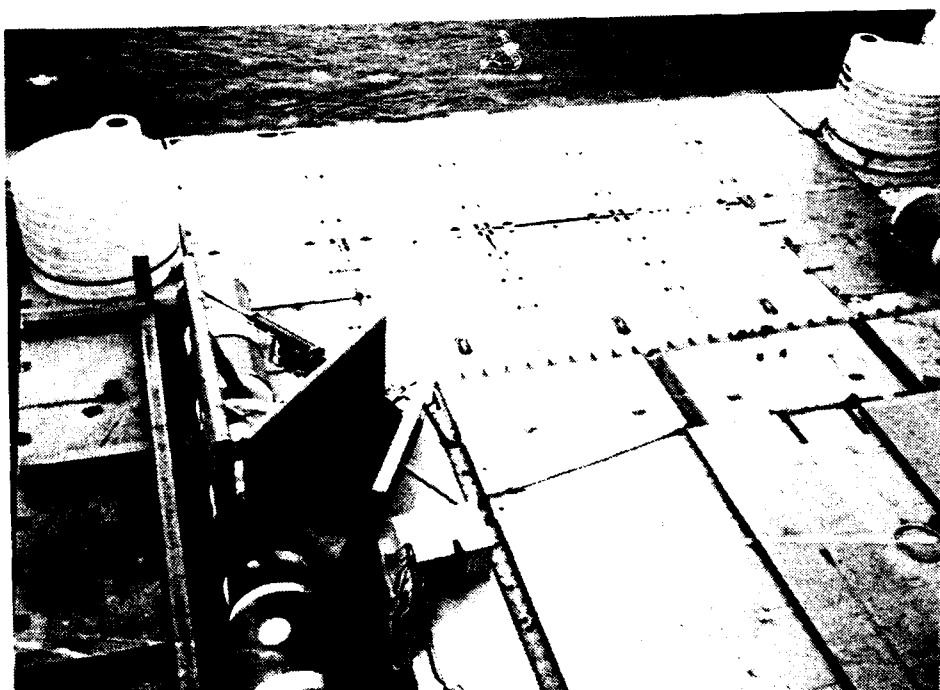


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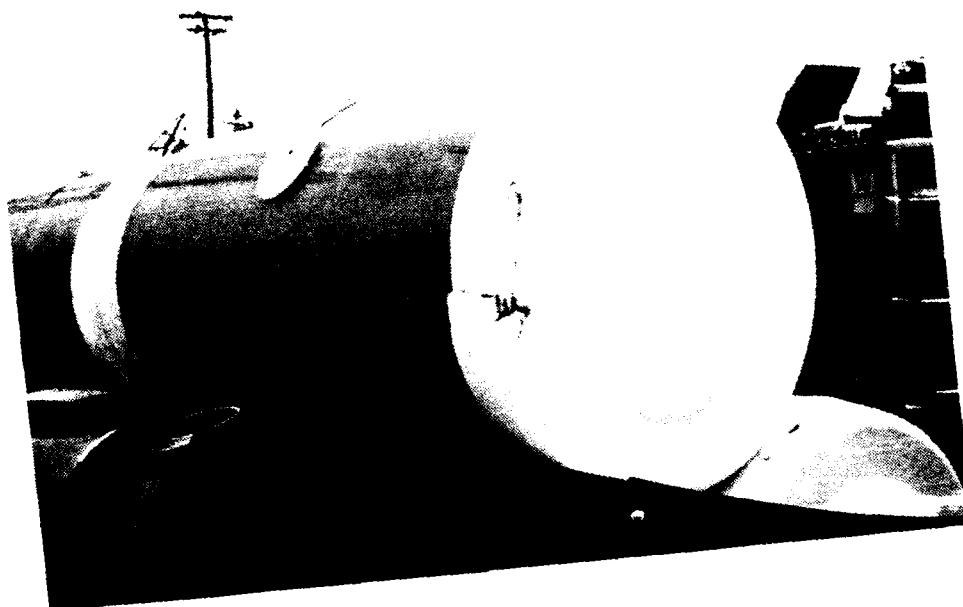


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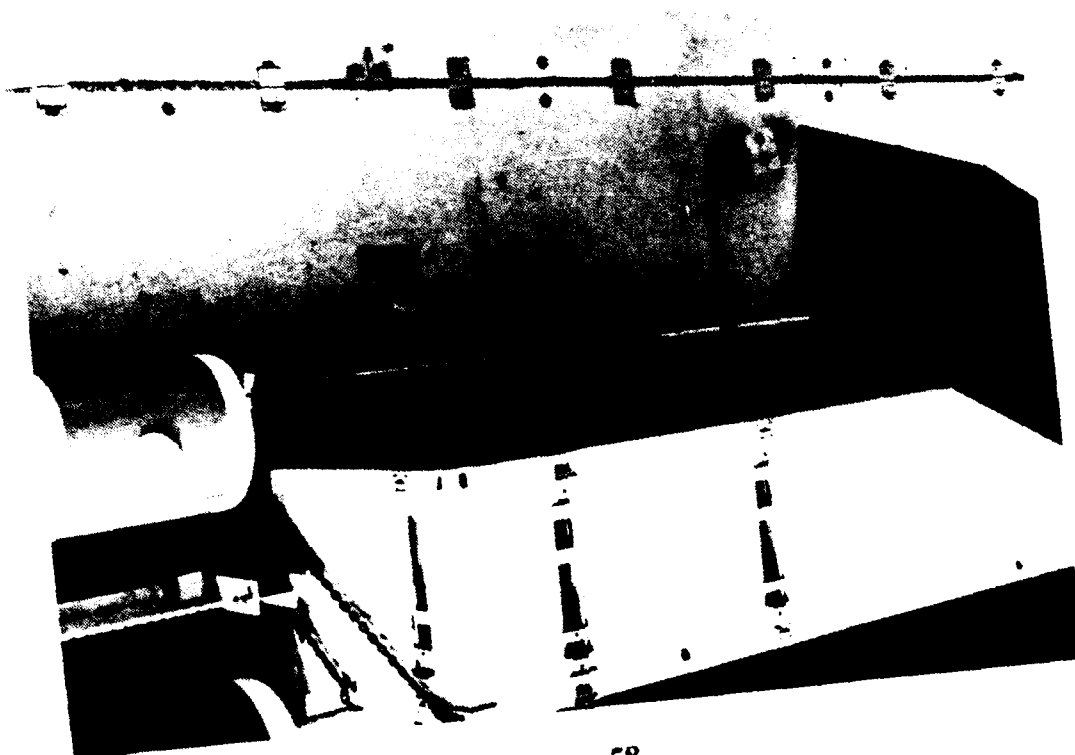


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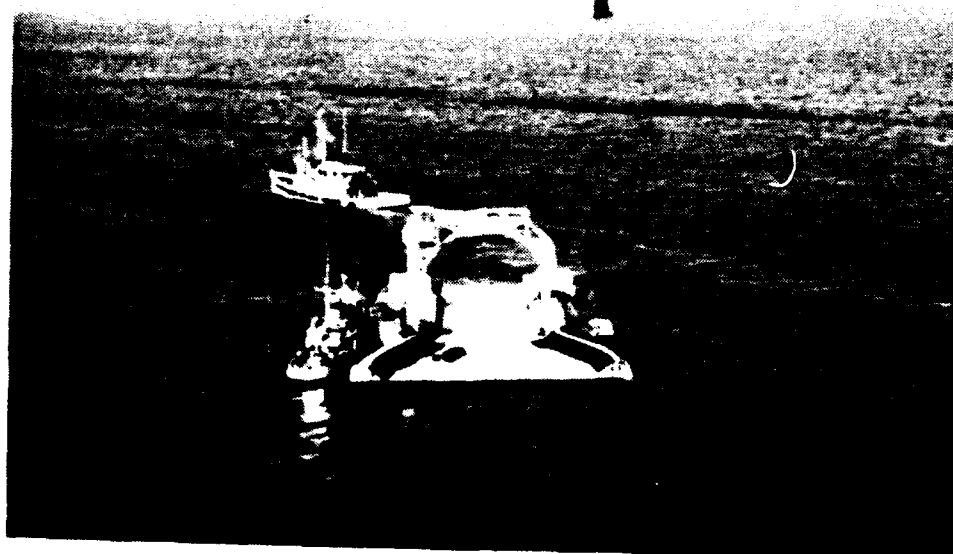


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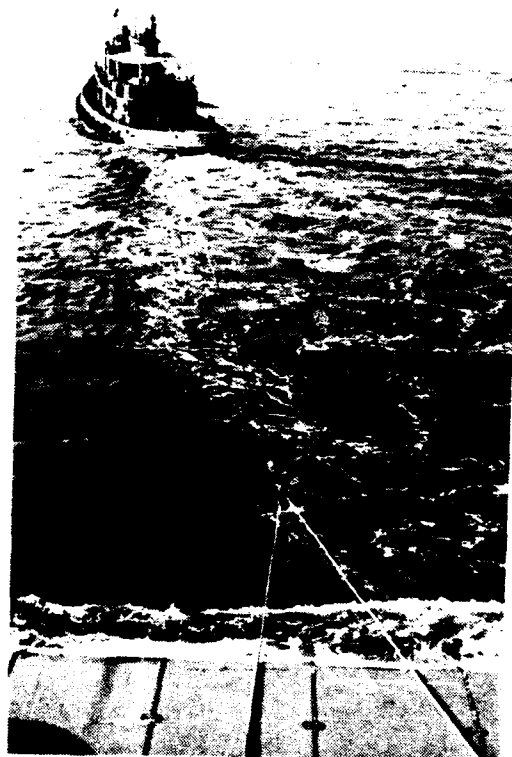


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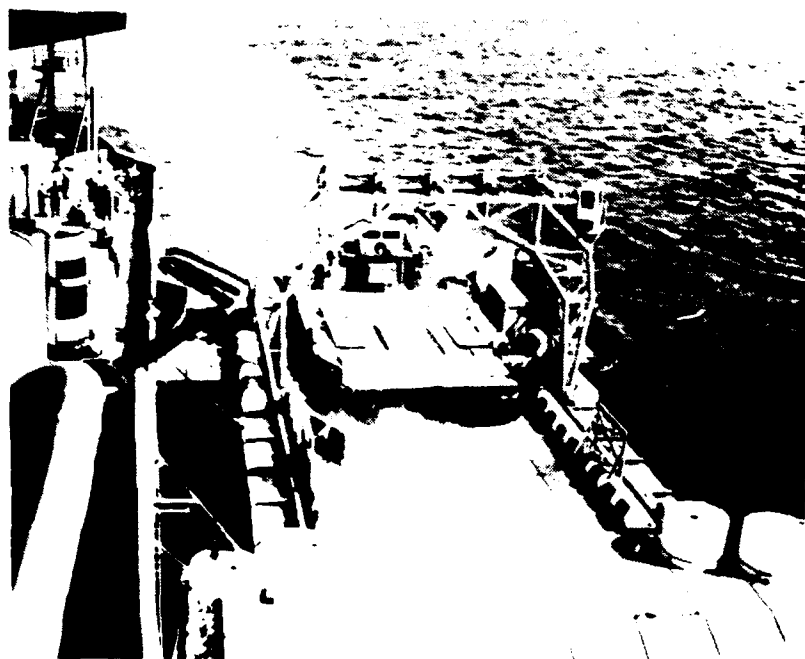


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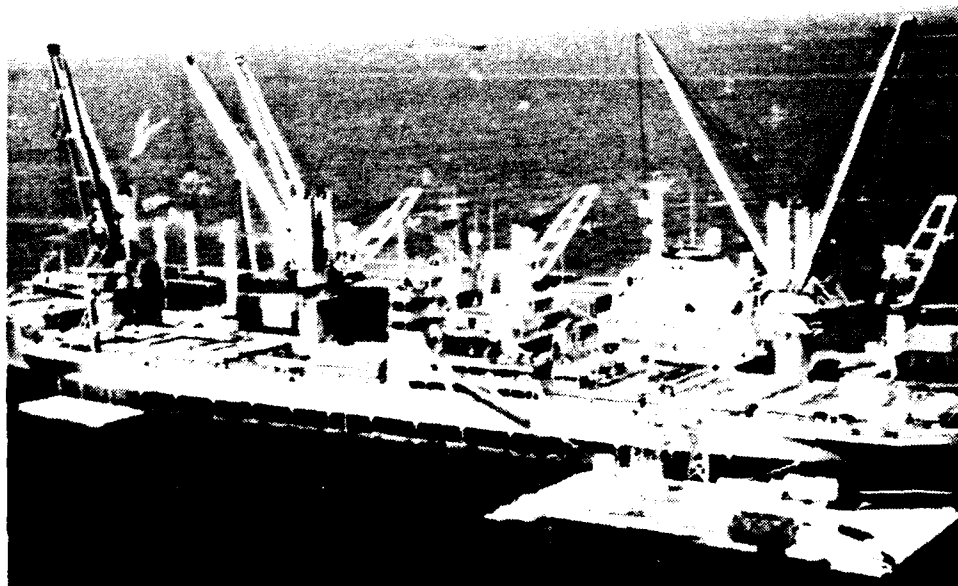


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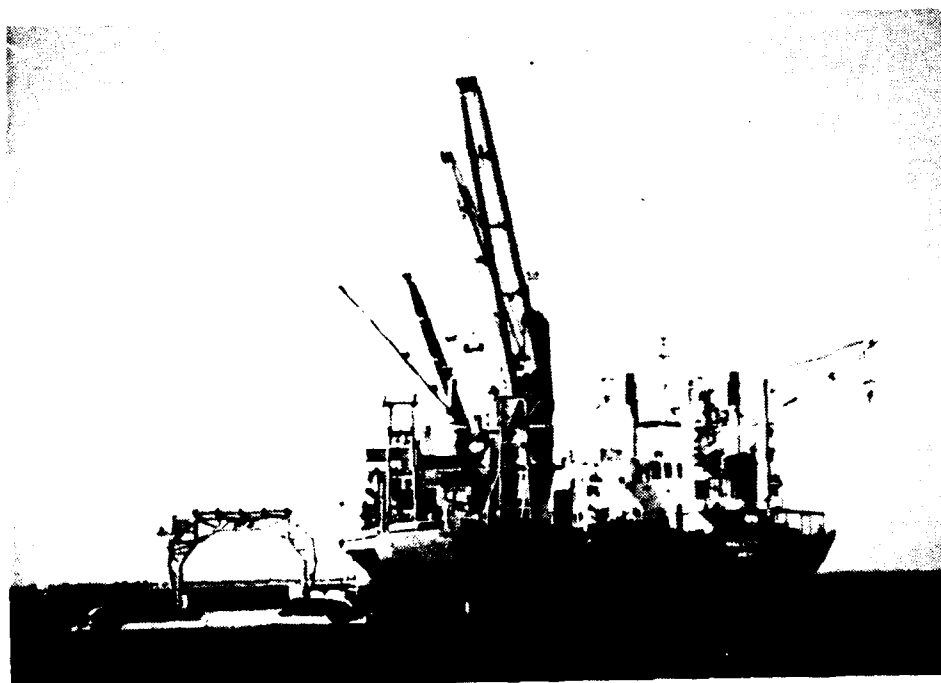


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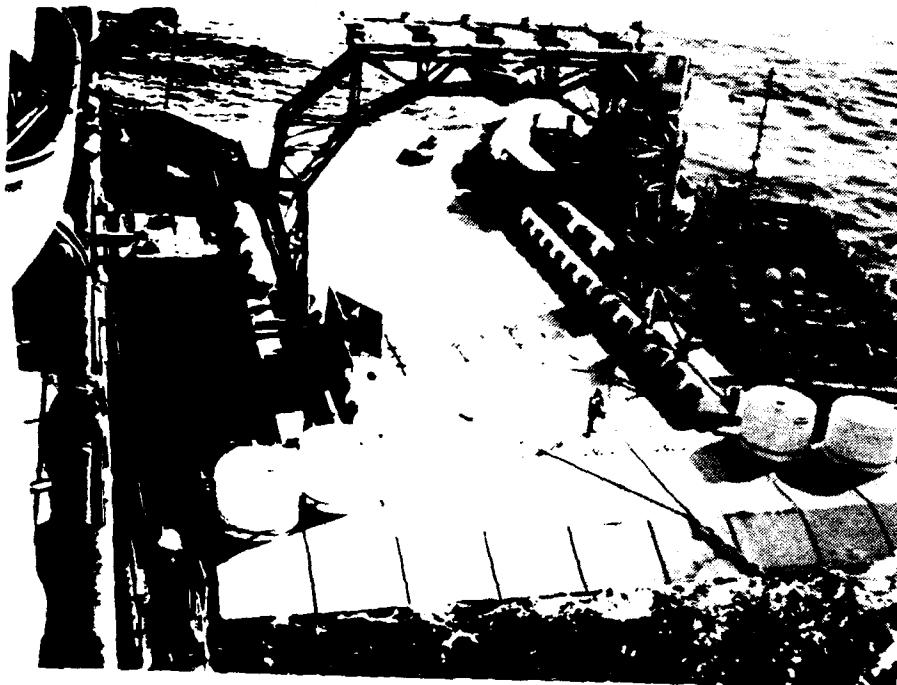


Photo 65



Photo 66



Photo 67



Photo 68



Photo 69

Appendix B

HISEACOTS

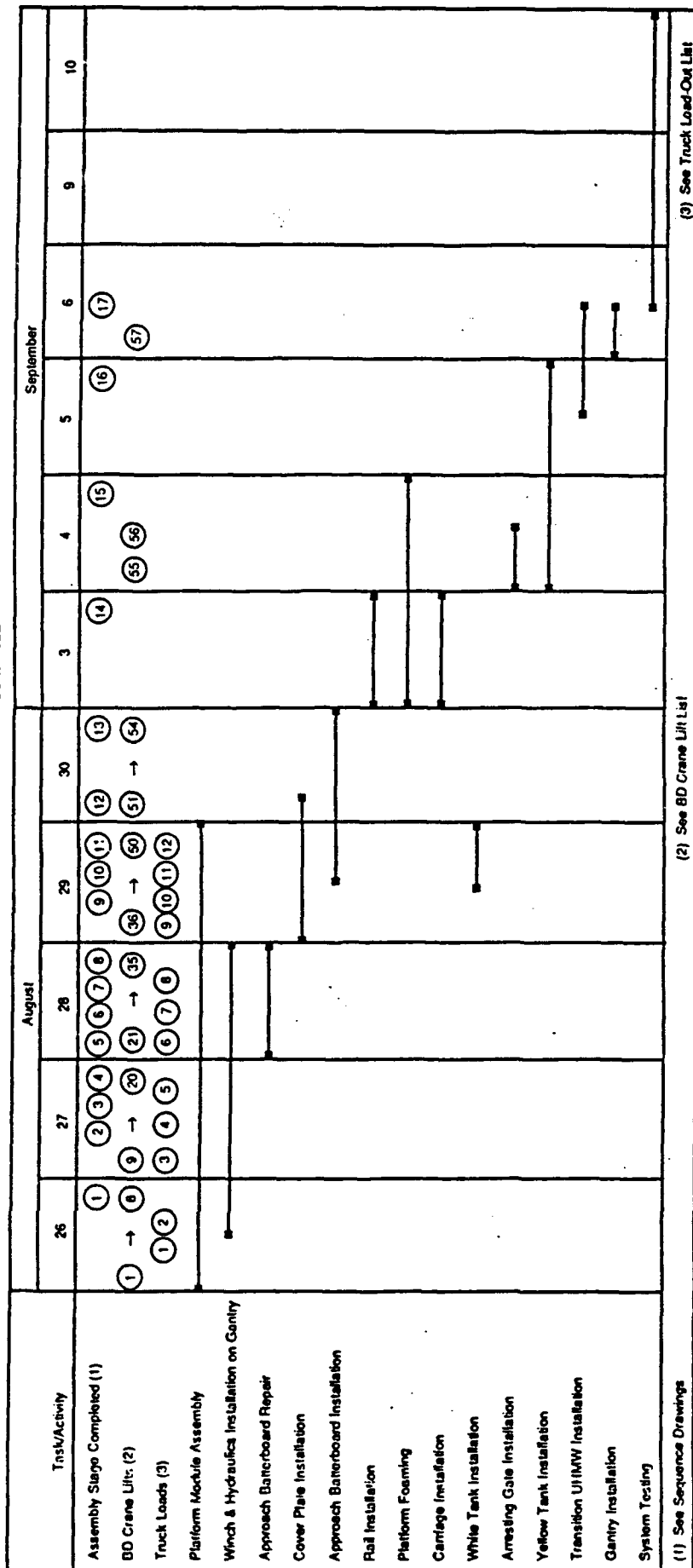
Assembly Sequence

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HISEACOTS 8/26 to 9/6 Assembly Schedule

HISEACOTS 8/26 - 9/6 ASSEMBLY SCHEDULE

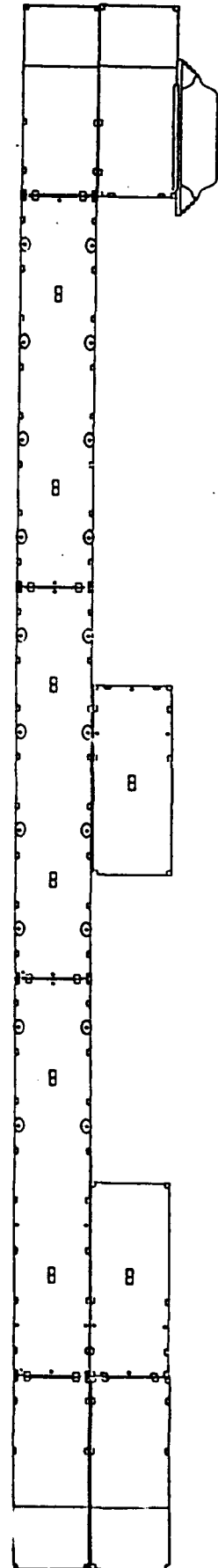


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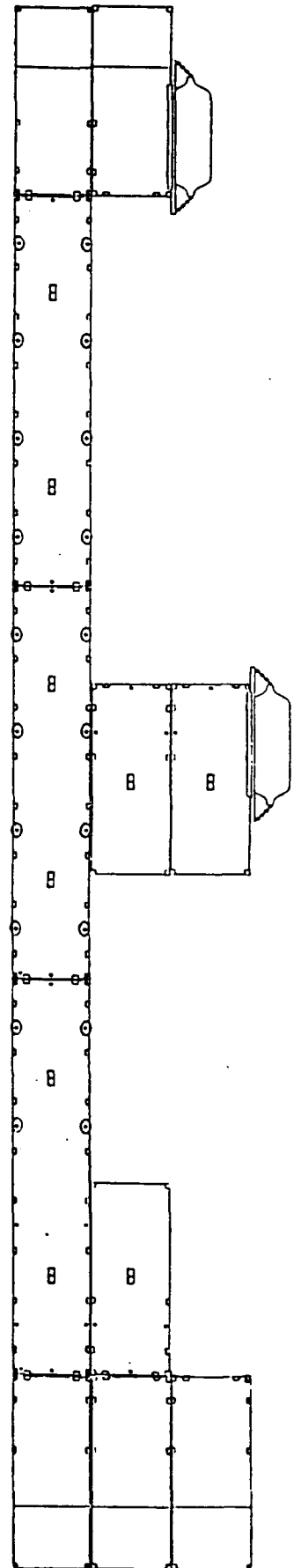
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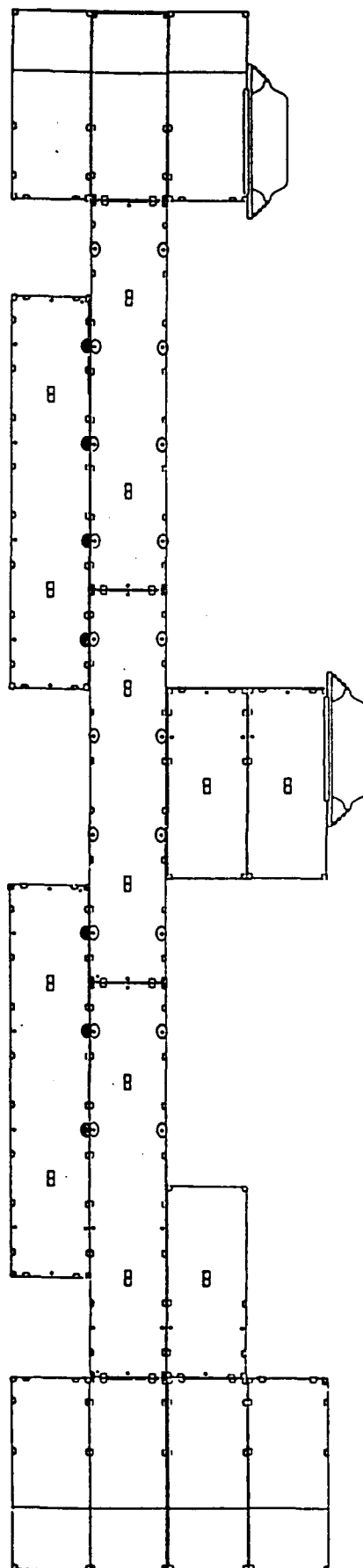
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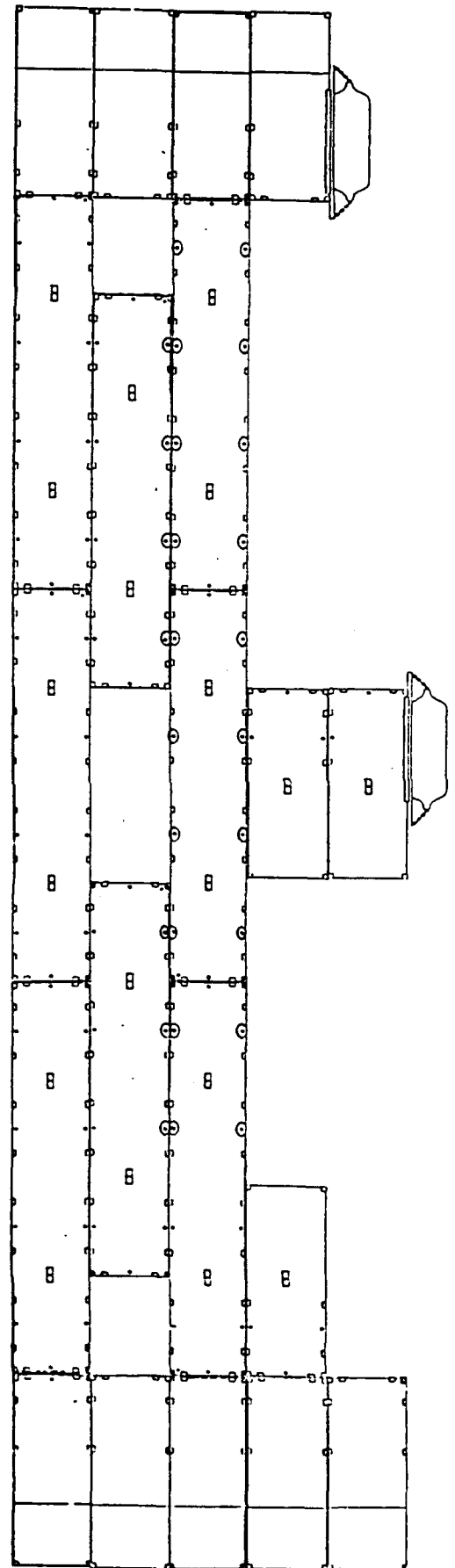
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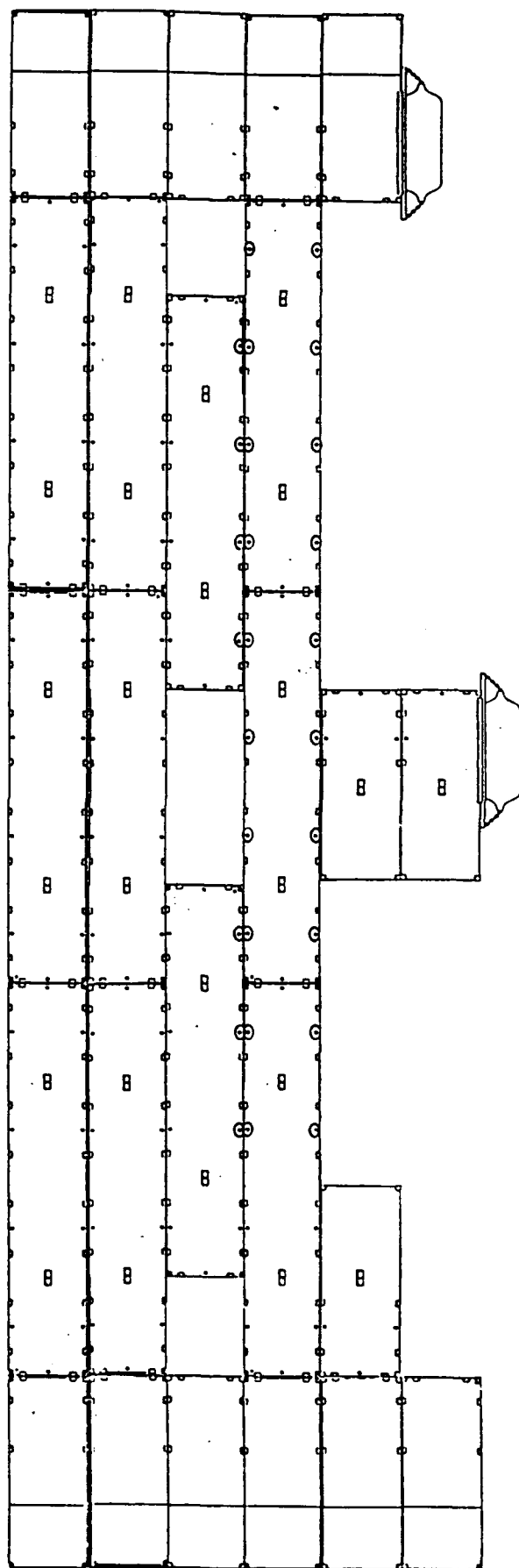
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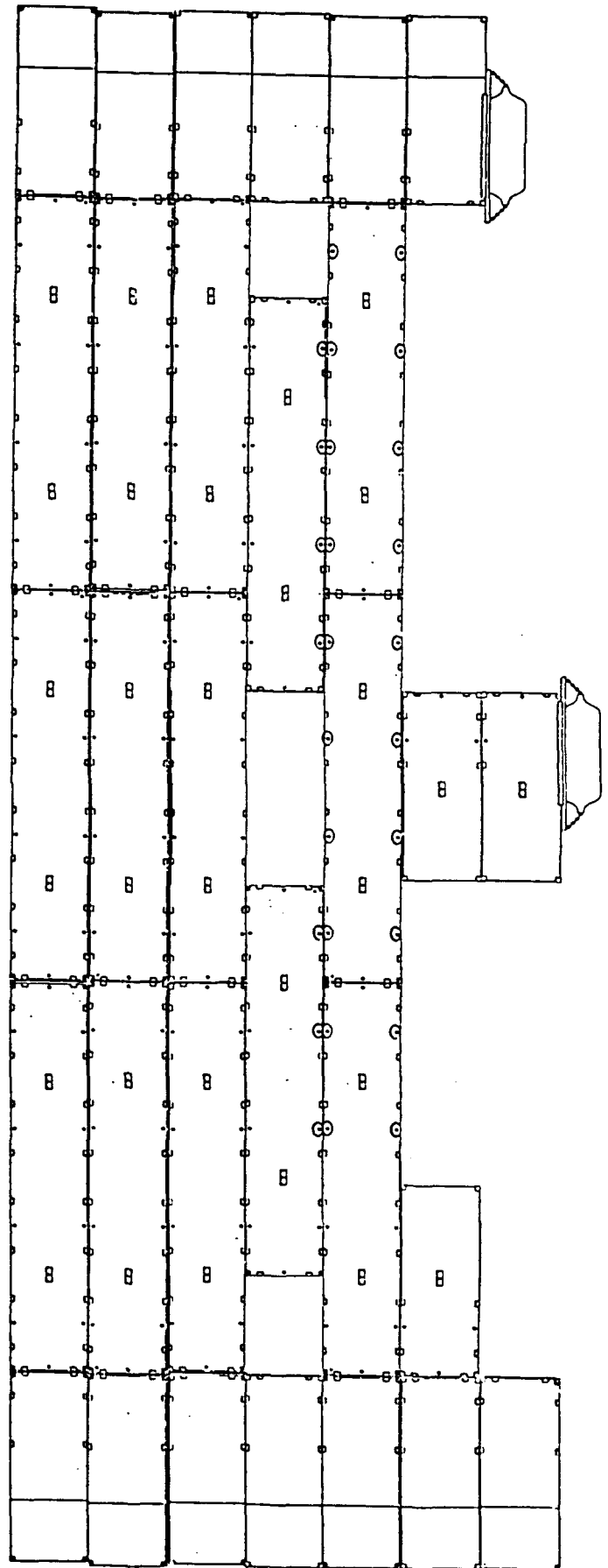
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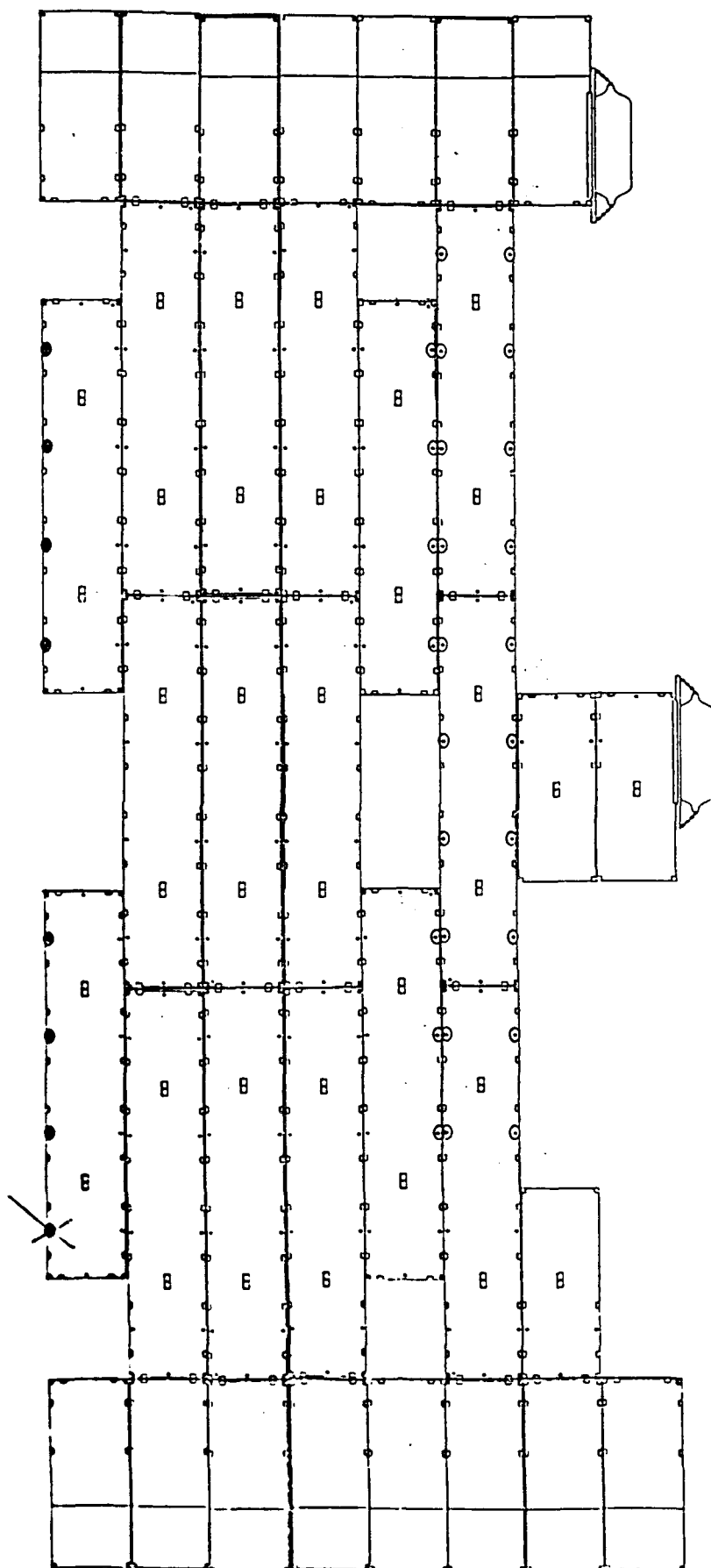
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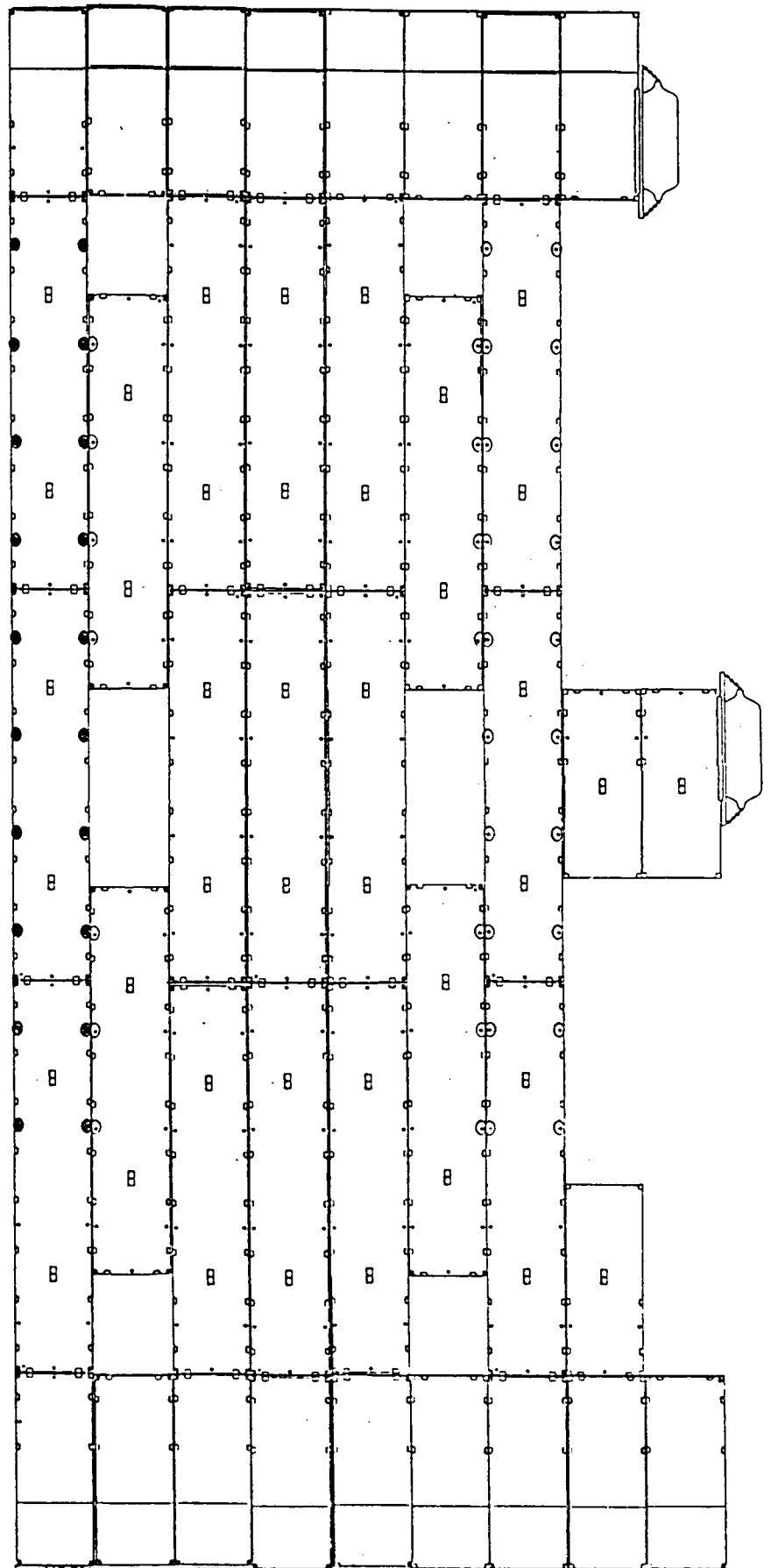
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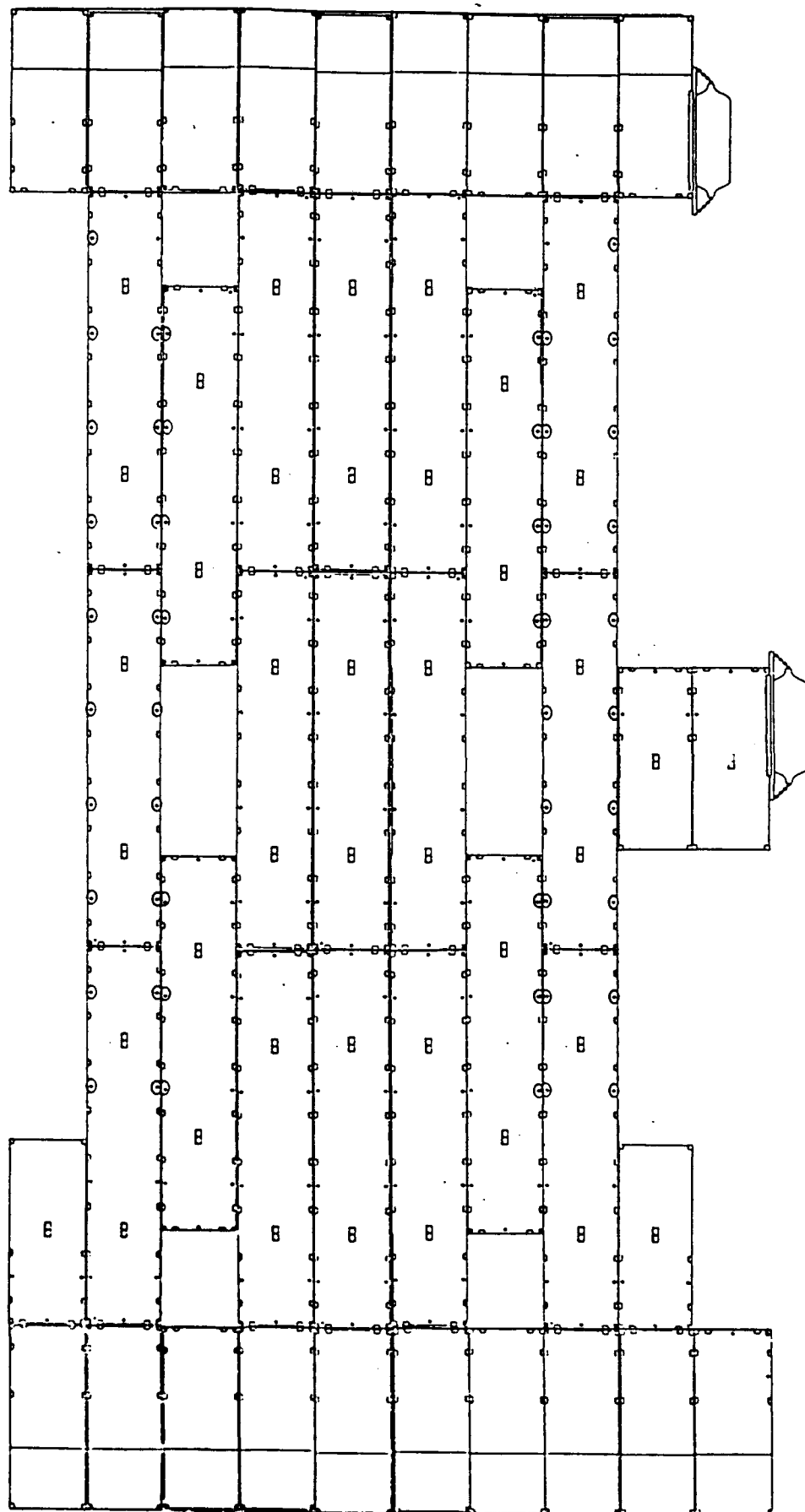
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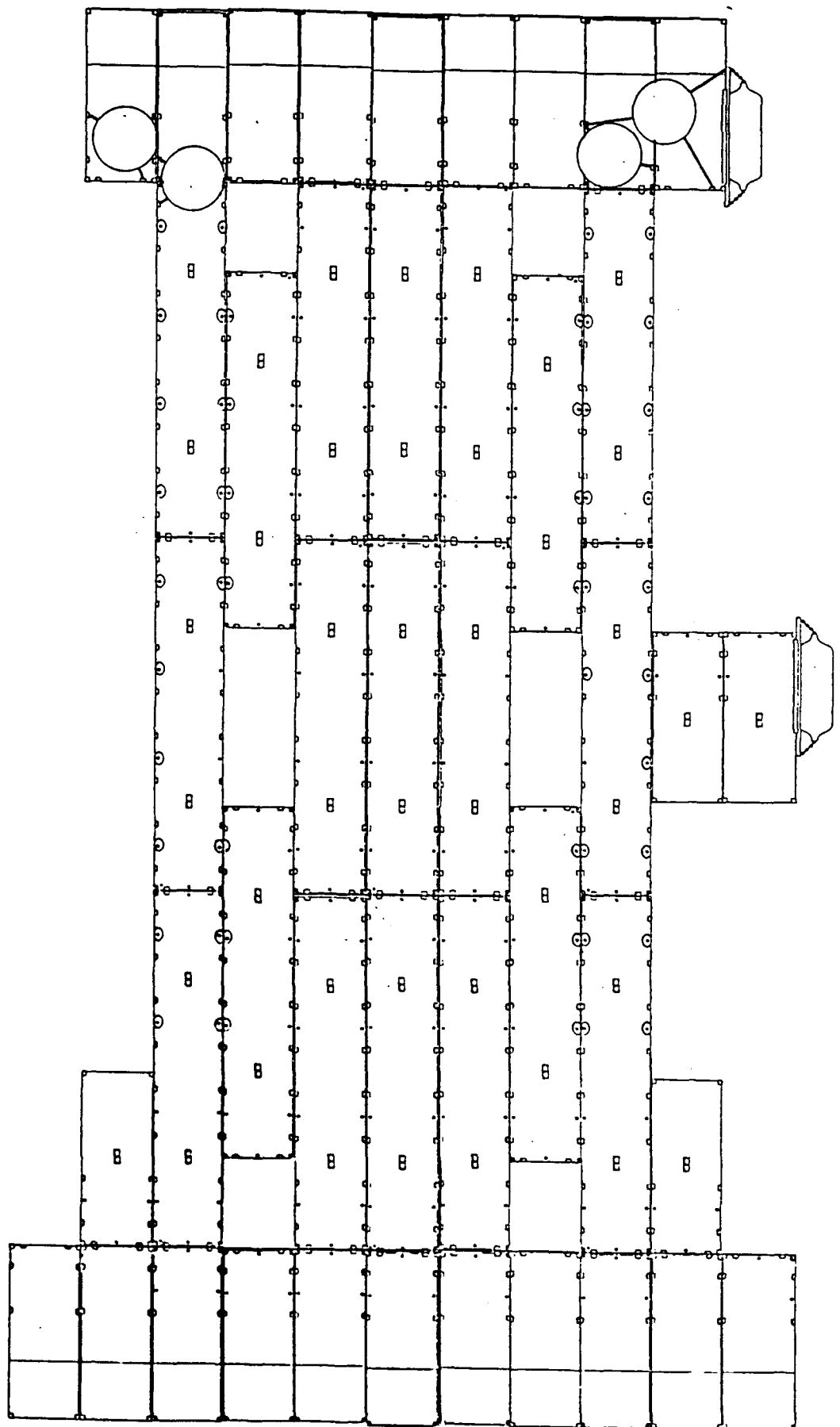
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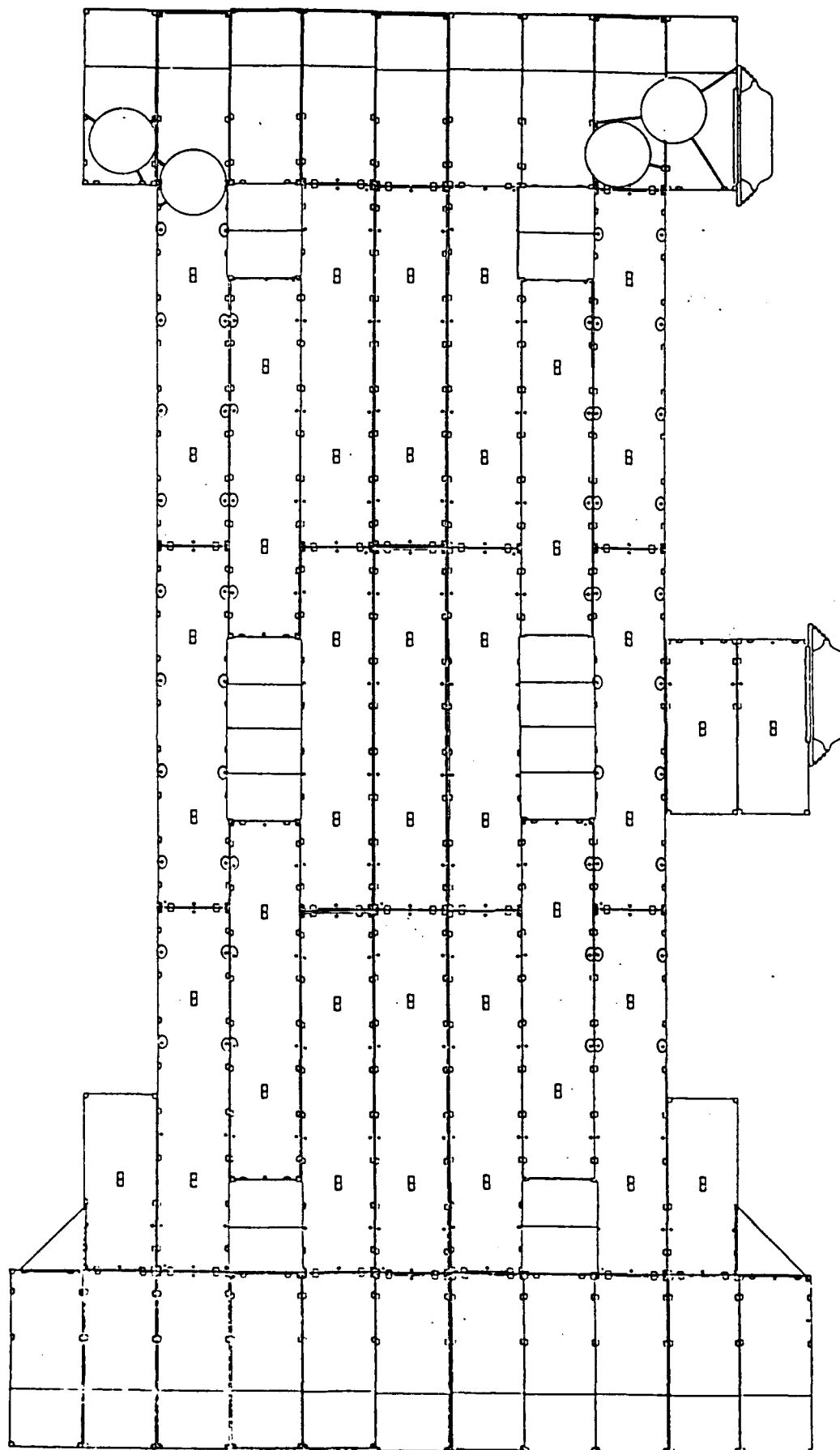
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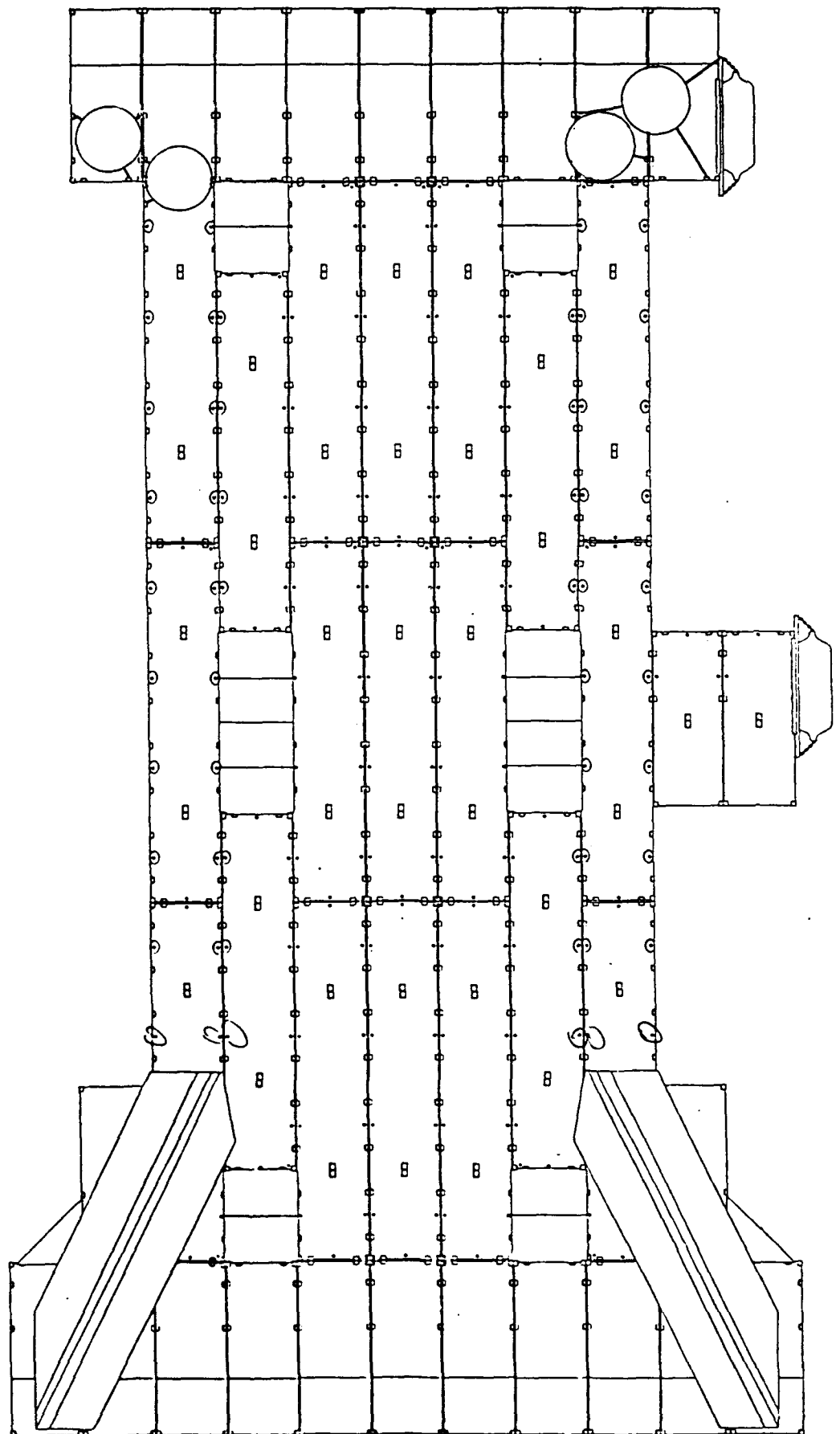
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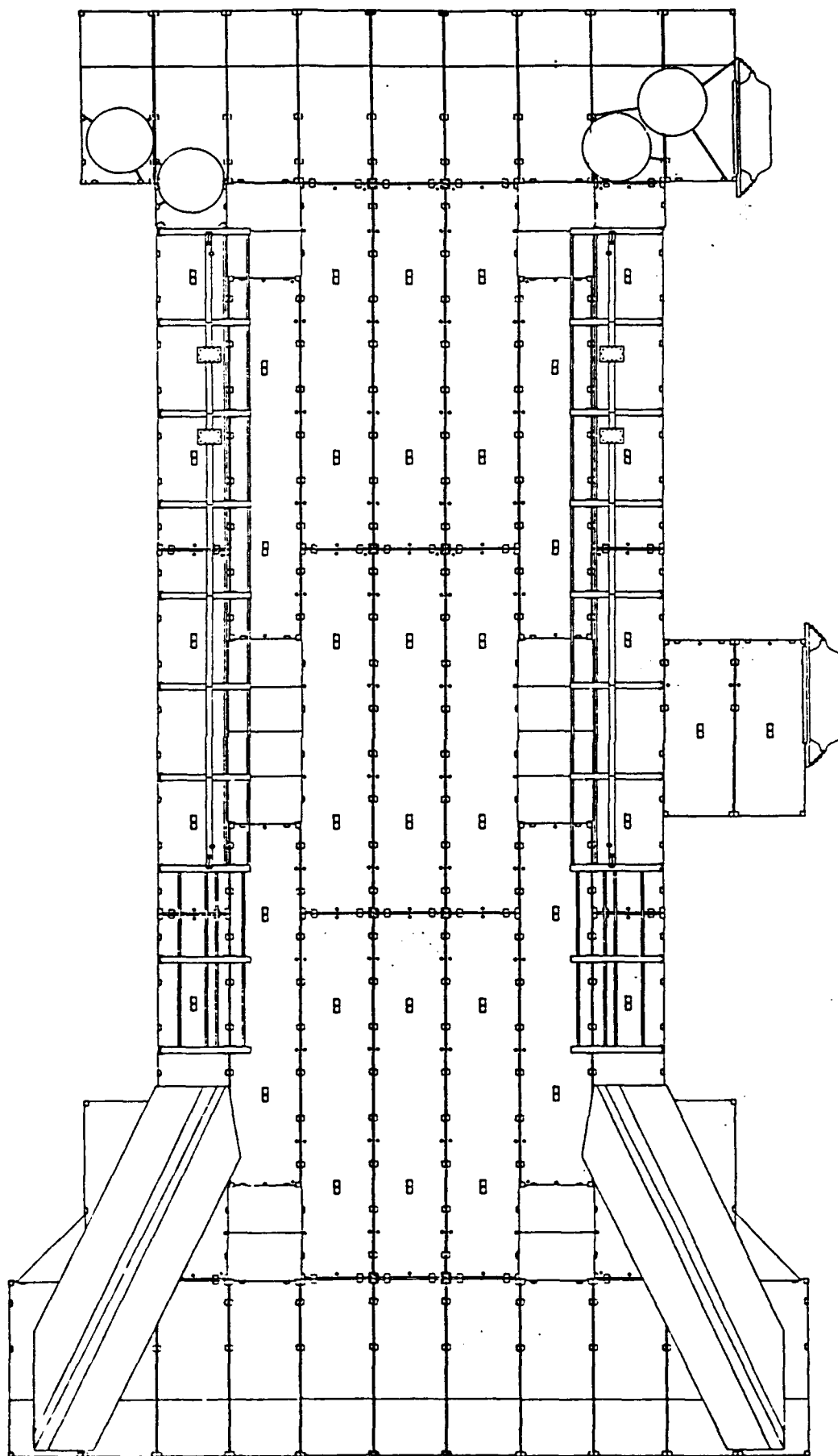
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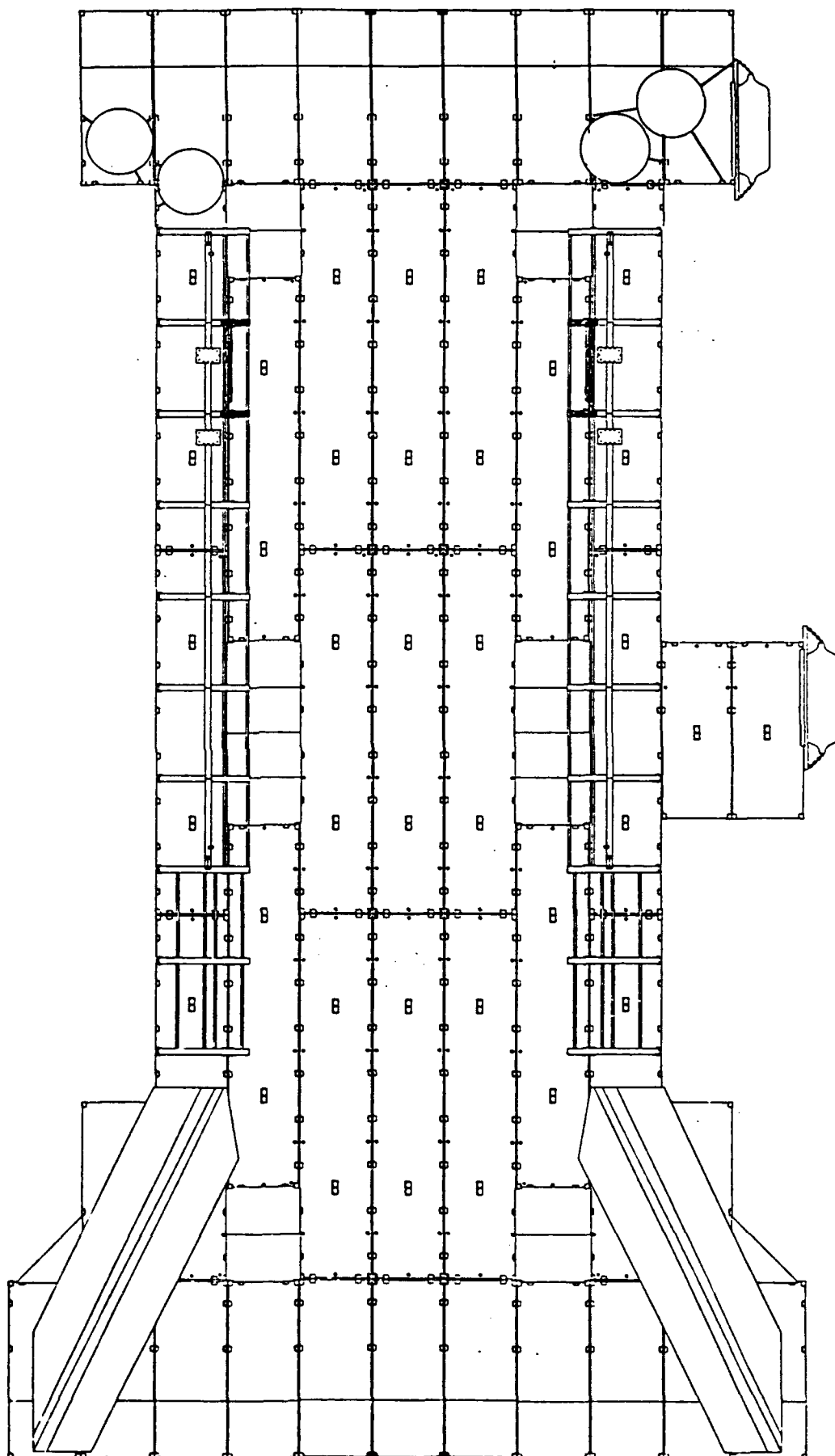
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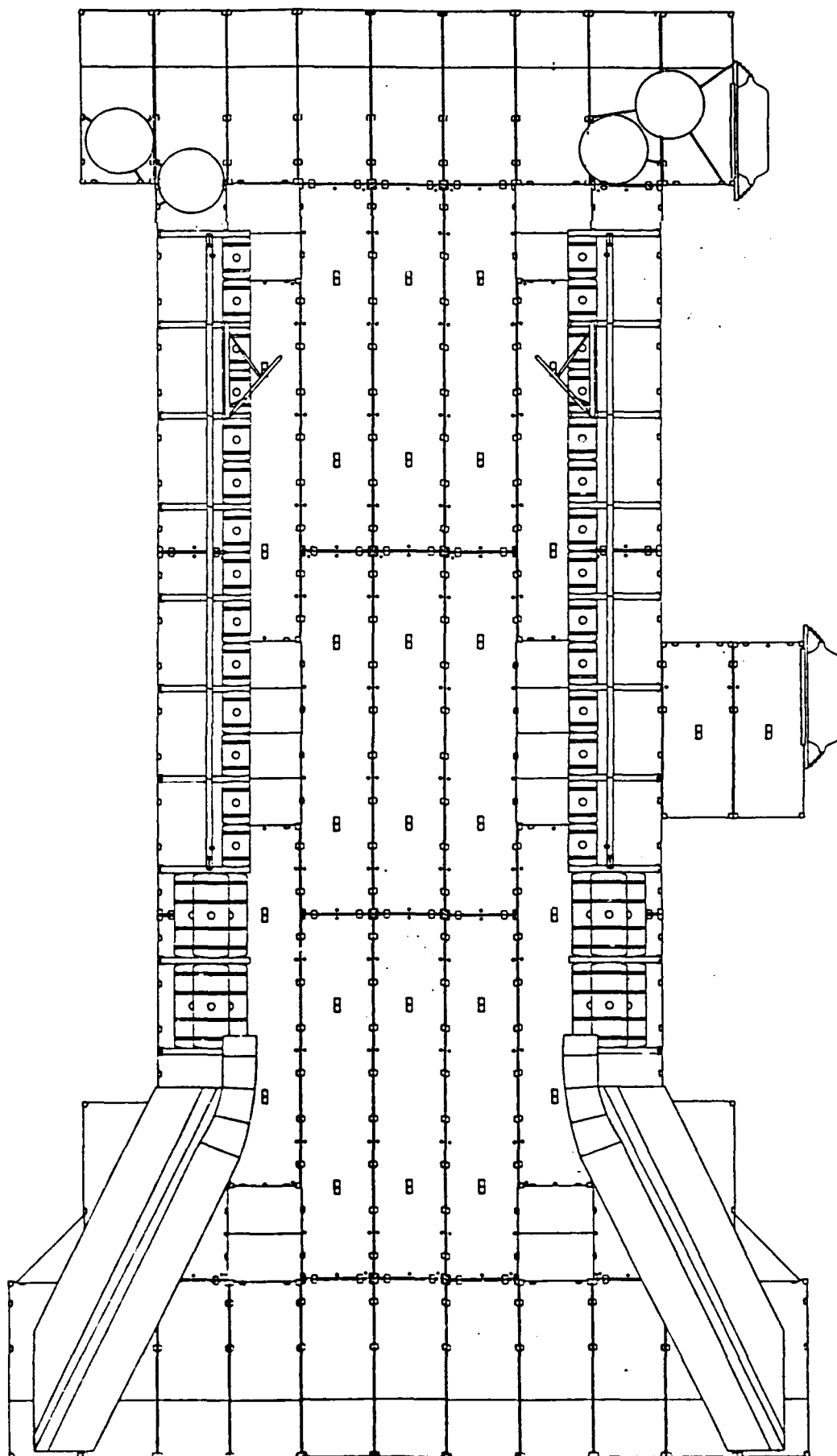
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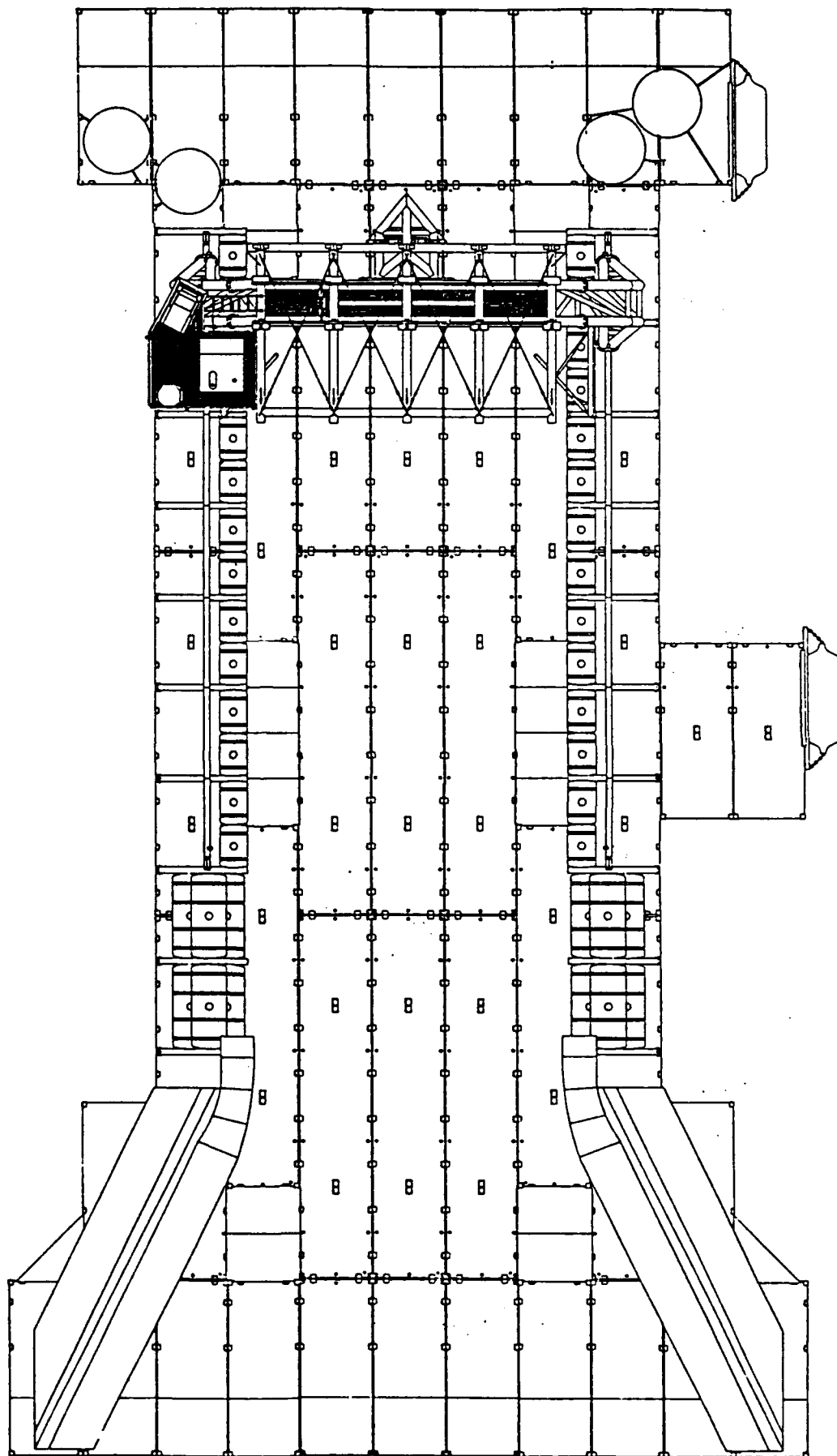
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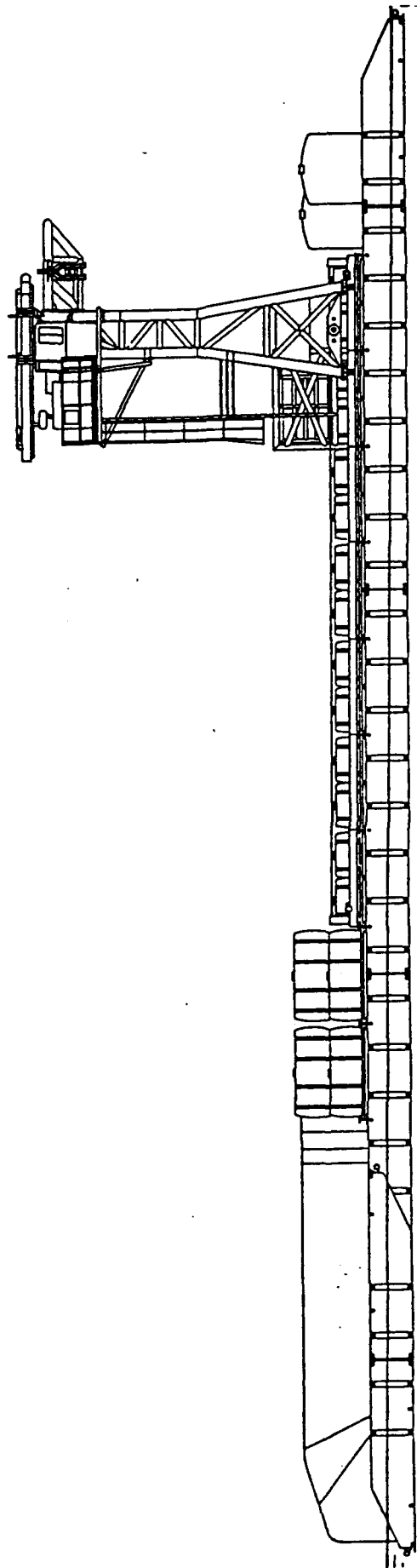
HISEACOTS Assembly Stage 16—Day 8



HISEACOTS Assembly Stage 17—Day 9



HISEACOTS Assembly Stage 17—Complete



Appendix C

Analysis of HISEACOTS Ramp-Joint Failure

**BAND, LAVIS
AND ASSOCIATES, INC.**
900 RITCHIE HIGHWAY, SEVERNA PARK, MD. 21146
TELEPHONE: (301) 544-2800 • (301) 261-1030

TECHNICAL MEMORANDUM NO. 284-3

TO: Brian David, BRDEC

FROM: Dan Wilkins, BLA, Inc.

DATE: 6 November 1991

SUBJECT: Analysis of the HISEACOTS Ramp-Joint Failure Which Occurred During the JLOTS III September Exercise.

The elemental forces on the HISEACOTS platform during the storm experienced at the Ft. Story JLOTS exercise, caused a mechanical failure of the joint between the departure ramp modules and the adjacent 40-ft modules. The analysis of this failure is presented herein.

Analysis of Platform Loads at Time of Failure

The mooring arrangement of the HISEACOTS at the time of the incident is shown in Figure 1. Also shown in Figure 1 are the estimated wind, wave, current and swell conditions just prior to the platform failure.

Figure 2 shows the estimated forces on the platform resulting from the conditions presented in Figure 1. These forces have been derived from data presented in Reference 1. The model experiments documented in this report relate to the testing of various configurations of large barge platforms in various conditions of current, waves and swell. One configuration which was tested is very similar to the HISEACOTS platform as shown in the comparison of Table 1. This platform was tested in sea and current orientations identical to those shown in Figure 1.

For the purposes of this analysis, it is presumed that all surge and sway forces were reacted on the forward fender module as shown in Figure 3. An additional load on this module was the weight of the departure ballast tanks, fully supported by the connectors as the platform end pitched free of the water. As seen in Figure 1, an additional spring line was rigged to resist sternwards surge. However, this longer line was more difficult to tension than the shorter forward spring line, and could stretch significantly more under a given load. Thus, it probably contributed little to reacting the surge loads. The forward fender was likely to have seen the full sway load at times.

A diagram of the probable worst-case loading on the upper inboard connector between the second-to-inboard ramp module and its adjacent module is shown in Figure 4. The connectors between the inverted raked-end 20-ft modules and the 40-ft module were designed and fabricated to bolt ISO corner-to-ISO corner. The necessity to invert the 20-ft module to form a ramp-end precluded use of the standard Isolog pin and guillotine connectors. Due to the presence of some play in the design of the Isolog connectors fastening adjacent 20-ft modules, it is reasonable to assume that these rigid connectors reacted the majority of the mooring loads.

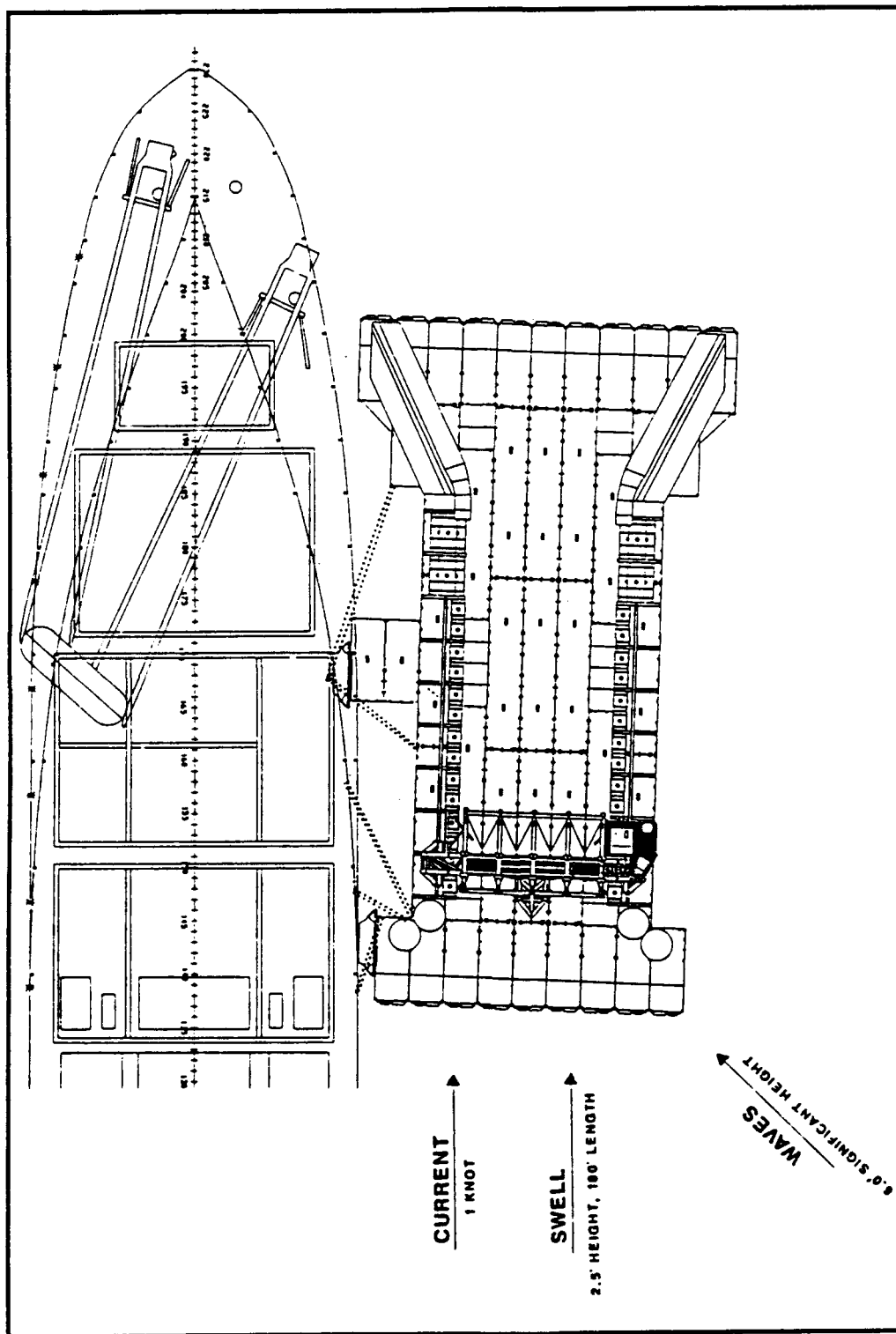


Figure 1. Mooring Arrangement and Sea Conditions

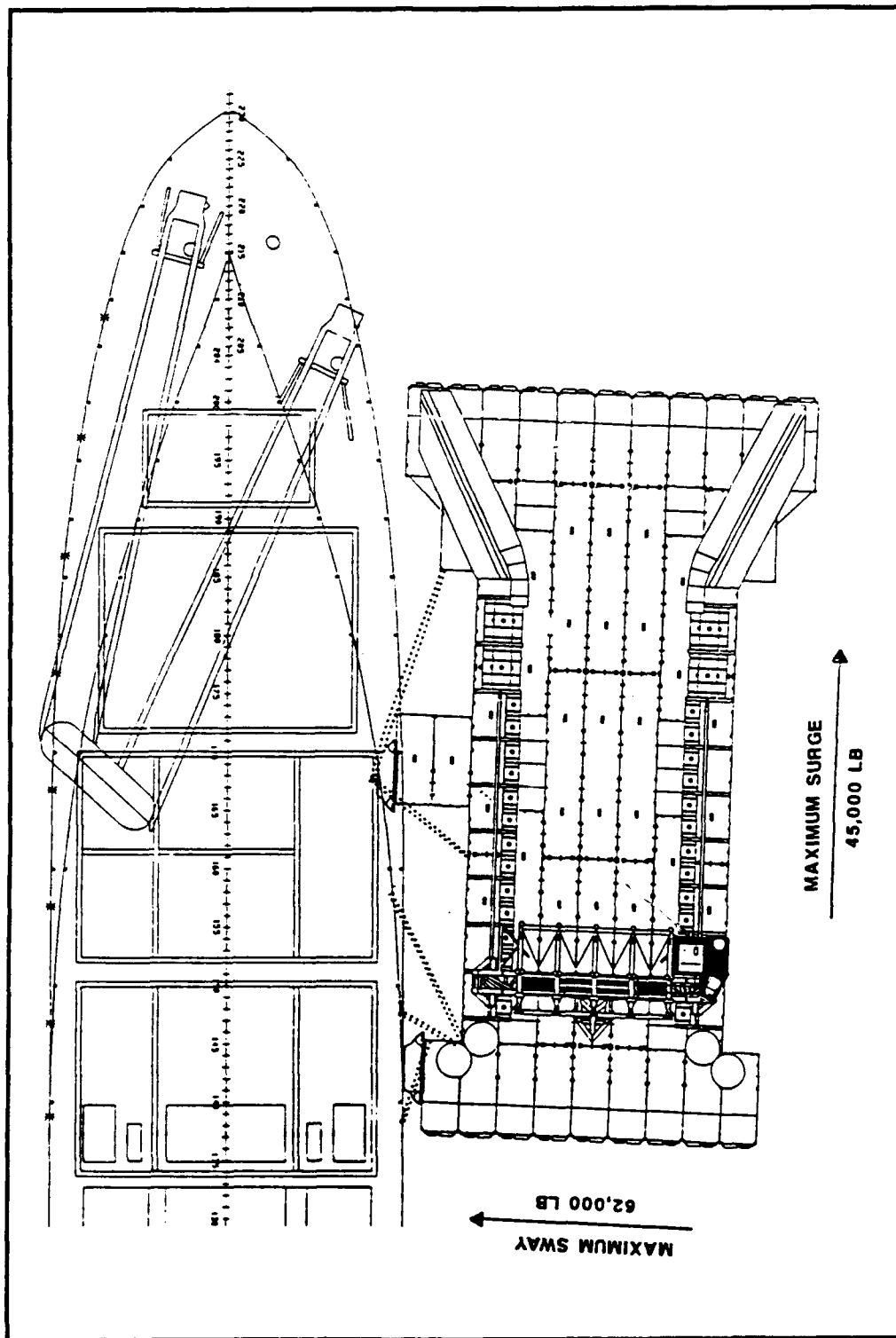


Figure 2. Platform Forces Resulting From Sea Conditions

Table 1

Comparison of RO/RO Platform and HISEACOTS Platform

RO/RO Platform	Dimensions* Displacement Wetted Surface	HISEACOTS Platform
65' x 180' x 5' 1,112,425 lb 15,865 ft ²		72' x 160' x 4.5' 1,257,600 lb 23,040 ft ²
*Does not include causeway ferry attached		*Does not include outermost approach ramp module

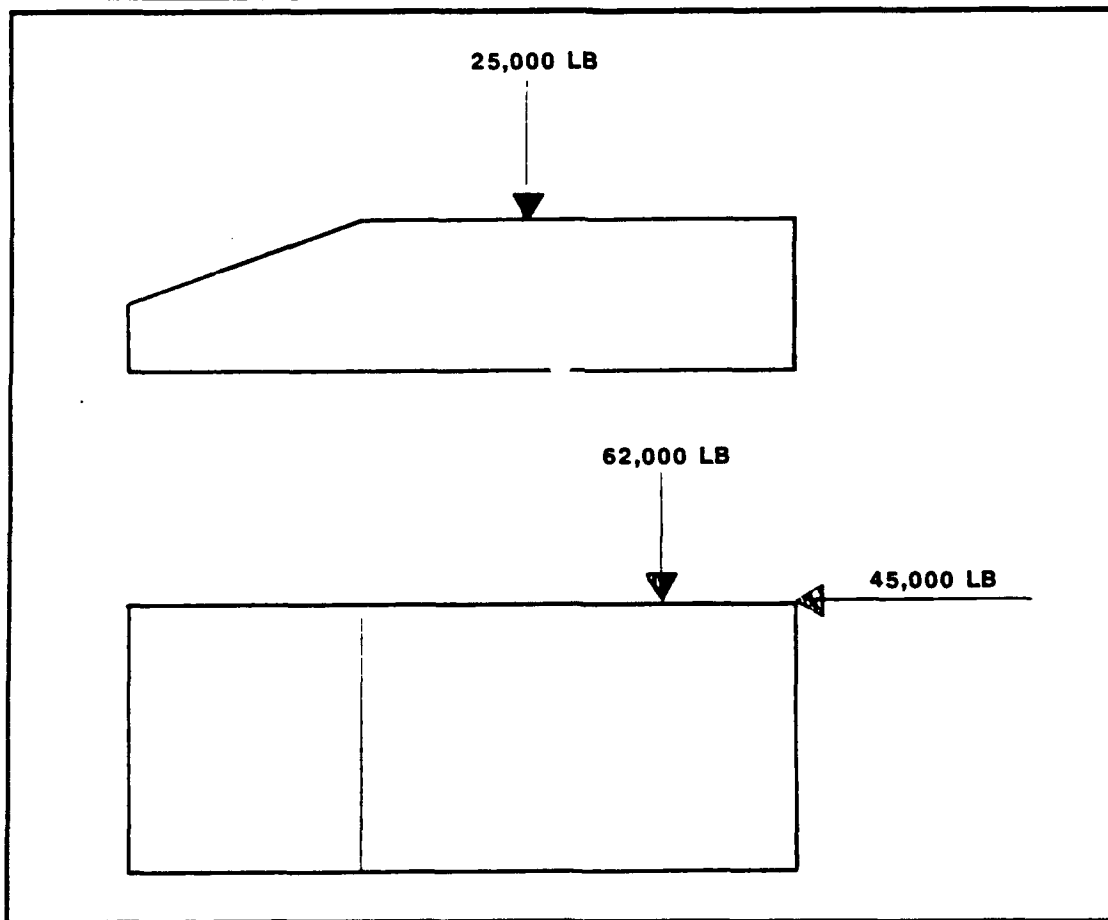


Figure 3. Loads Acting on Forward Inboard Fender Module

The ISO corner-to-ISO corner connectors are shown in Figure 5. The calculated strength of these connectors is compared to the advertised strength of the Isolog connectors in Table 2.

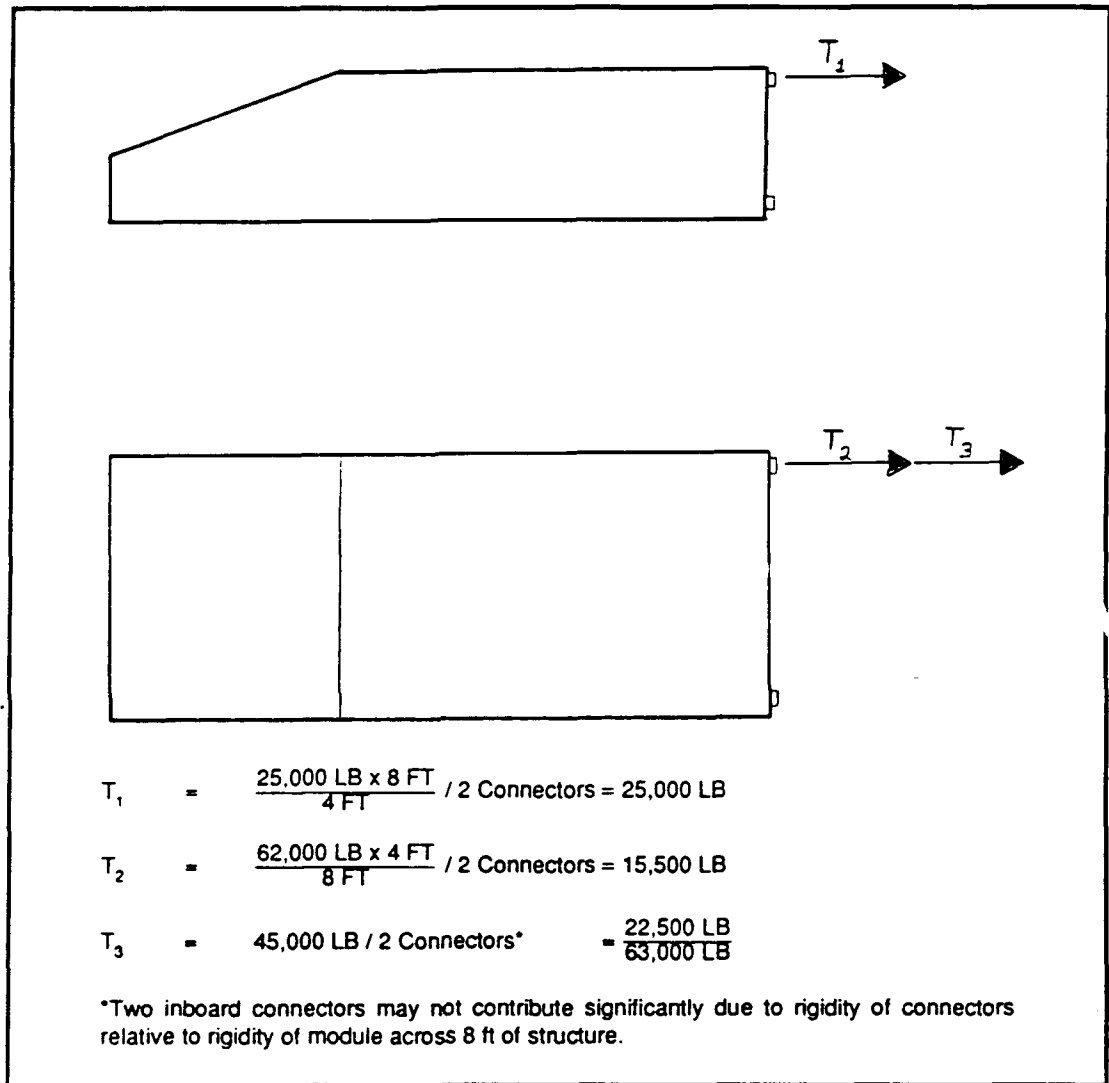


Figure 4. Tensile Loads in Upper Inboard Connector of Forward Fender Module

It is evident from the analysis presented herein that the design of the fendering and mooring arrangement was poor relative to concentrating loads on a single set of module connectors. However, the calculations would not predict the tensile failure of the ISO corner connectors under the conjectured sea conditions. Shear loads are also calculated to be well below the connector strength (no shear failure of the connector lugs was observed).

Sea conditions during the storm, and particularly alongside the T-ACS ship, were most probably more severe at some point in time than those assumed in Figure 1. Another possible load would be a "suspension" of the forward inboard platform corner by the mooring lines under severe pitch motions, however,

this load would act opposite to the weight of the ballast tanks and severe pitching was not observed. The possible random dynamics involved with the platform-ship interface are incalculable.

Table 2

Comparison of Isolog Connector and ISO Corner Connector

Isolog Connector*		ISO Corner Connector*
150,000 lb	Tensile (65% Yield)	120,000 lb
230,000 lb	Ultimate Tensile	185,000 lb
230,000 lb	Ultimate Shear	220,000 lb
*From Robishaw		*From Calculations

Plans for Future Operations

It is planned to fabricate special Isolog pins to fasten the raked-end ramp sections to the 40-ft sections in subsequent HISEACOTS assembly. This is being done primarily to facilitate assembly procedure. As shown in Table 2, the Isolog pin is somewhat stronger than the special connectors previously utilized. Also, the ability of the Isolog connector to flex somewhat may improve the "toughness" of the ramp-to-platform joint. The modifications intended to improve the fendering and mooring capability of the HISEACOTS and allow for it to remain alongside ship through sea state 4 are as follows:

1. Remove all fender and mooring line attachments to the ramp modules.
2. Distribute mooring line attachments so that a significant number of pin connections are effective in reacting the load.
3. Provide a portable deck winch so that all mooring lines may be equally tensioned.
4. Utilize bitts or cleats to terminate mooring lines at the HISEACOTS to facilitate tensioning and to provide for ready release.
5. Utilize three shipside fenders to better distribute loads.
6. Strengthen fender attachments to their support frames (the Sea Guard fenders are good for 136,000 lb sway loads each, but, at some point, attachment chains were broken).
7. Reduce the overall width of the platform by 16 ft. (This is being done partly for transportability and partly for platform survivability).

The proposed mooring and fendering arrangement for HISEACOTS in subsequent operations is shown in Figure 6.

An emergency mooring system will also be provided to allow for HISEACOTS survival in sea states through sea state 6. The probable arrangement of this system is shown in Figure 7. The system will be designed for readily deployment with either the T-ACS ship or an anchoring system serving as the mooring point.

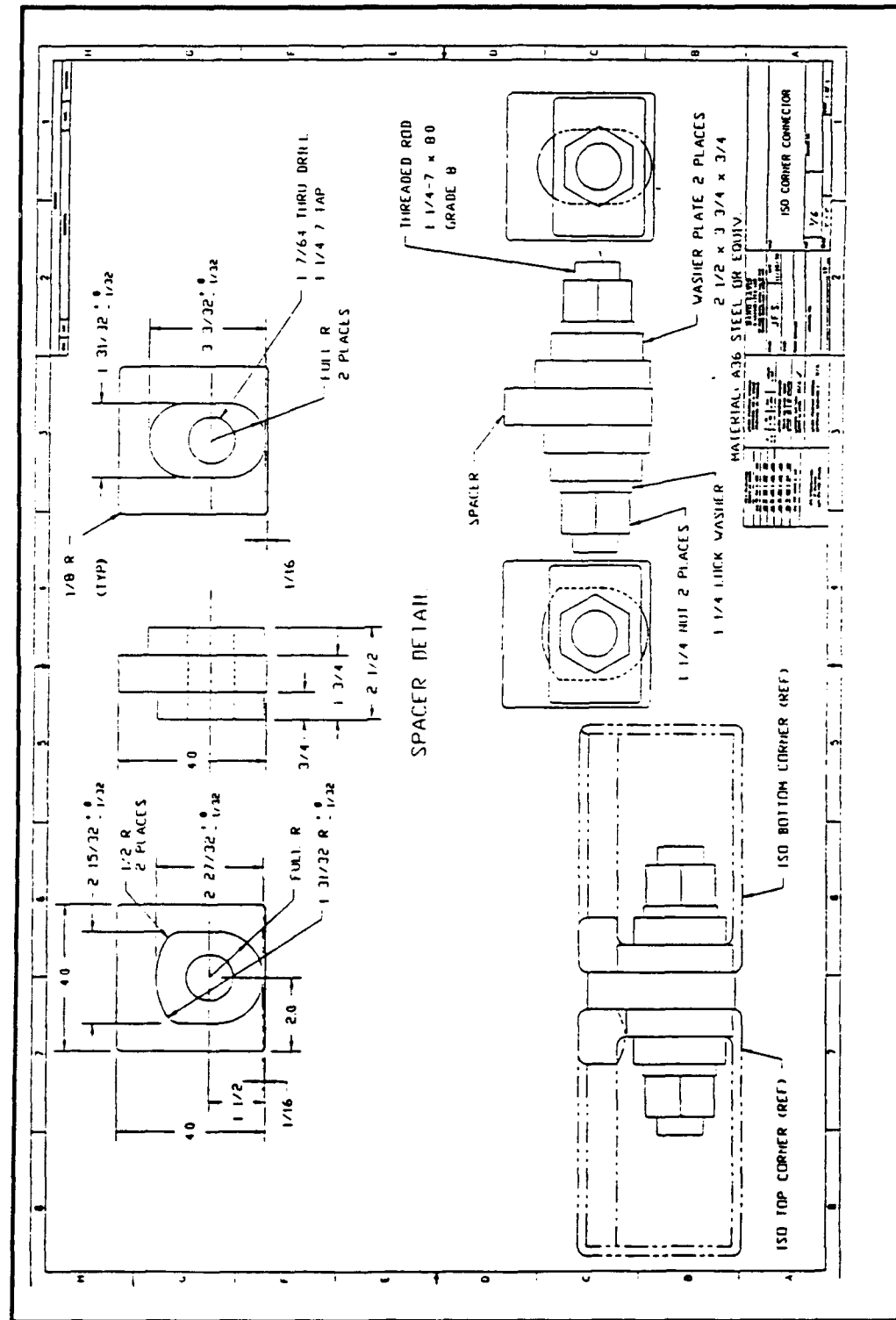


Figure 5. HISEACOTS ISO Corner Connector

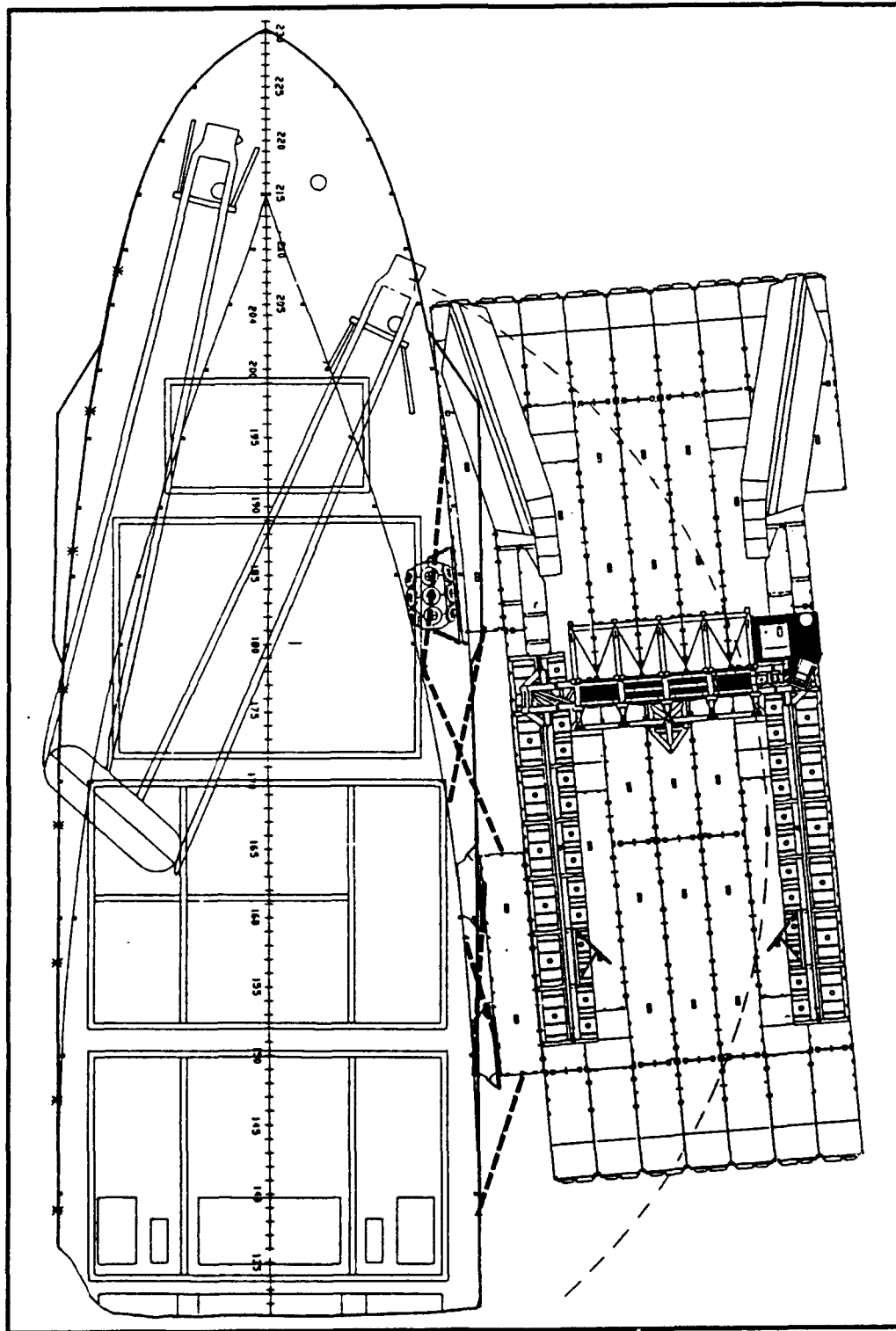


Figure 6. Proposed Mooring and Fendering Arrangement for HISEACOTS

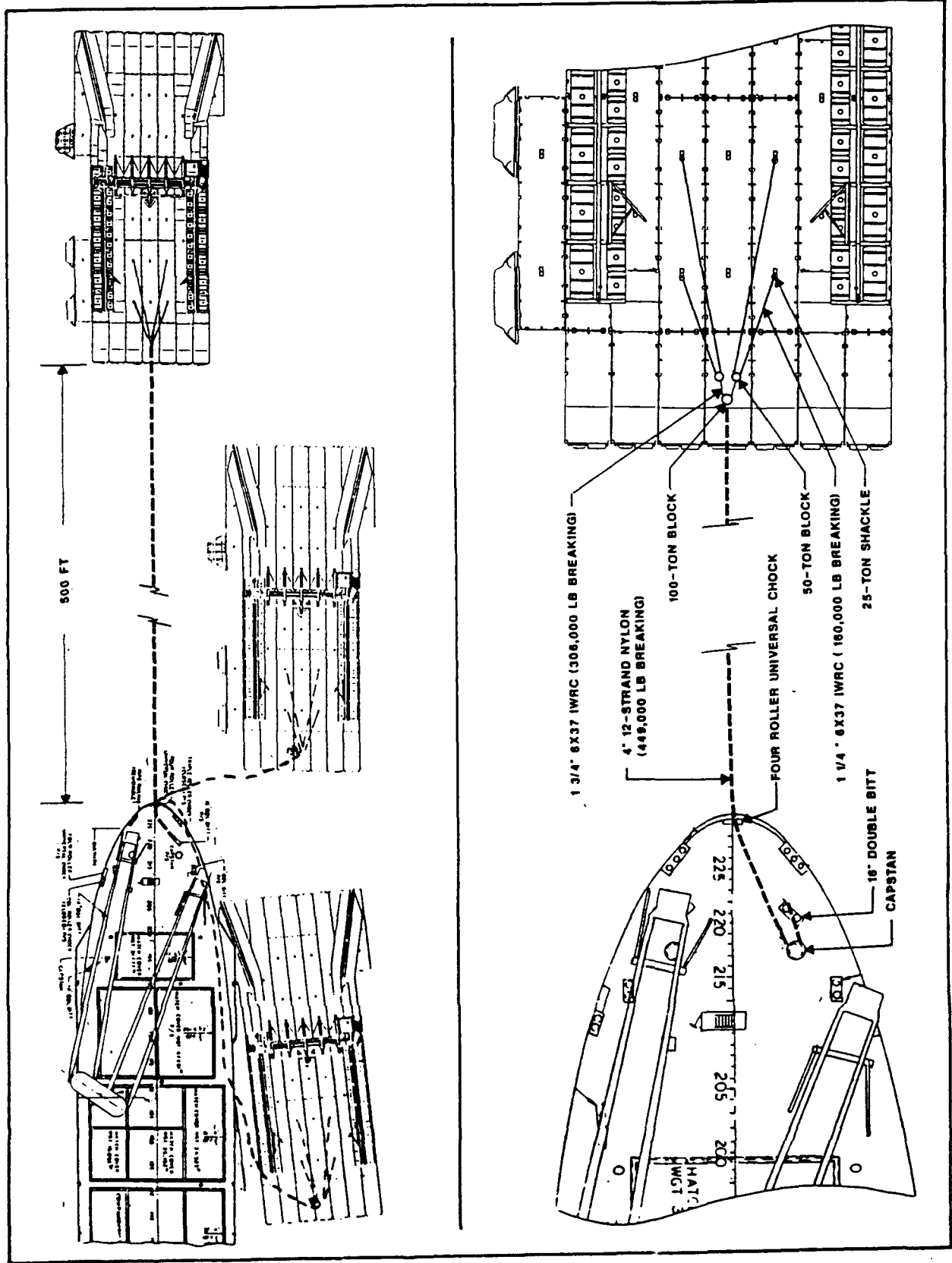


Figure 7. Emergency Mooring System

References

1. "Model Experiments of RO/RO Ship Offloading System in Waves and Current," Zarnick, Turner and Hoyt, DTNSRDC/SPD-1046-01, December 1982.

Appendix D

Preliminary Failure Analysis of Two Broken HISEACOTS Couplers



REPLY TO
ATTENTION OF

DEPARTMENT OF THE ARMY

US ARMY BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR, VIRGINIA 22060-5606

STRBE-VL

3 December 1991

MEMORANDUM FOR Marine Development Team, ATTN: STRBE-FMD (Mr.
Brian David)

SUBJECT: Preliminary Failure Analysis of Two Broken HISEACOTS
Couplers

1. The High Sea State Container Transfer System (HISEACOTS) recently was damaged during a sudden storm when participating in the Joint Logistics-Over-the-Shore III (J-LOTS III) exercise. Mr. Brian David of the Marine Development Team (STRBE-FMD) had delivered one new and two broken steel ramp couplers (or connectors) plus one new nut and one used large hex nut to this laboratory for failure analysis. The couplers are used to connect modular sections of the ramp to the end of the HISEACOTS main platform. According to the information provided by Mr. David, the ramp broke loose from the platform during the storm.
2. A ramp coupler is composed of a 1½-inch diameter by 7 inches long continuous thread stud threaded midway into a square center plate with a ½-inch thick protrusion machined on each side. An oblong-shaped protrusion on one side of the plate would fit into the oblong opening of the ISO corner casting welded to the modular section of the ramp or platform, whereas the D-shaped protrusion on the other side of the plate fits into the D-shaped opening of the corner casting. The coupler is attached to two castings with a ½-inch thick rectangular plate washer, lock washer and 1½-inch diameter size hex nut on each end of the stud. The nuts are tightened inside the castings to connect the ramp to the platform. Both the studs and nuts are supposed to be SAE grade 8.
3. Visual examination of the broken couplers with the remaining stud revealed that one end of the stud had broken from the oblong side of the plate. The broken ends were not included with the broken couplers for examination. Both couplers, including the fracture surface of the broken studs, were severely corroded from exposure to the sea water. In addition, the machined oblong protrusion and the center plate of one coupler were severely dented. The broken studs were removed from the center plates when the plates were cut in two to facilitate the removal of the studs. The stud that was removed from the badly dented coupler had a slight bend at the D-shaped protrusion side of the center plate. Also, the appearance of the fractured surface would indicate that the failure mode of this bent stud was be shearing. The other broken stud was straight; however, the features of its fractured surface indicated brittle failure, probably by sudden overloading.

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SUBJECT: Preliminary Failure Analysis of Two Broken HISEACOTS Couplers

4. The used hex nut was examined visually. Its internal threads showed extensive wear on one side, indicating that the nut may have come loose during service. This nut, which has a metallic coating, did not have a distinctive grade marking required for SAE grade 8 hex nuts, or even grade 5, indicating that it was a lower strength grade, presumably grade 2.

5. Chemical analyses, hardness tests and microstructural examination was performed on the bent stud and used nut. The results of those analyses and tests revealed that the stud was made from a medium carbon alloy steel similar to alloy 4140 and quenched and tempered to a hardness of 31.5-32 HRC (Rockwell C scale), whereas the nut was made from a low carbon steel similar to grade 1018 with a hardness of 72-74 HRB (Rockwell B scale) which is considerably below Rockwell C scale. The nut was not heat treated. It was zinc-coated (galvanized) by hot dipping process, and its dimensions indicated that it was a standard hex nut.

6. According to SAE Standard J429 for externally threaded fasteners and J995 for steel nuts, SAE grade 8 studs are to be made from a medium carbon alloy steel, quenched and tempered to a hardness of 33-39 HRC, whereas grade 8 nuts can be made from a steel with carbon content up to 0.55% maximum and heat treated to a hardness of 26-36 HRC. The steel for grade 8 nuts must have the appropriate hardenability, depending on the size, to meet this hardness requirement. SAE grade 5 and 8 hex nuts are to be marked for grade identification, and grade 2 nuts are not required to be marked. Based on the above requirements and on the results obtained thus far, the coupler stud met SAE grade 8 requirements, even though it's hardness was just below the hardness limit, and the coupler nut was considered to be grade 2 rather than grade 8.

7. After a discussion with Mr. David regarding the incidents occurring to HISEACOTS during the storm, the use of SAE grade 2 hex nuts may be the preliminary culprit resulting in failures of the couplers. The drawing for the coupler did specify SAE grade 8 for the stud; however, it did not specify the grade for the nuts. Apparently, an assumption was made that when grade 8 studs were specified, then grade 8 nuts would also be used in the coupler. What may have happened to cause failures in the couplers on the HISEACOTS was that several grade 2 hex nuts may have come loose during the service to the point that they finally came off one end of the studs, thus causing additional strains on the remaining couplers as did the straight stud which eventually broke due to overloading. The extent of damage to the bent stud

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and its center plate may indicate that the exposed end of this stud, when the nut came off, snapped off as the result of ramp bumping against the end of the HISEACOTS main platform after the ramp broke loose during the storm. The above scenario leading to the failures of the couplers is only a speculation at this time, based on the examination of two broken couplers and a used nut.

8. Unfortunately, the locations of two broken couplers and one used nut examined were not recorded, i.e., the exact location of the failed couplers in the corner castings of the HISEACOTS modular sections. Suggestion is made to obtain more broken couplers. If possible, the broken stud ends and nuts also should be obtained in order to determine more positively the cause of the coupler failures.

9. POC for this action is the undersigned, x45471. --The Soldier's Command.



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